ARI Research Note 91-21

The Selection of an Experimental Test Battery for Aviator Cognitive, Psychomotor Abilities and Personal Traits

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In late 1986, the U.S. Army Aviation Center (USAAVNC) redesigned the Initial Entry Rotary Wing (IERW) course for aviator candidates. The new training is called IERW Multi-Track (IERW-MT) and became operative in May 1988. The research problem for the U.S. Army Research Institute Aviation R&D Activity (ARIARDA) was to develop tests and procedures for selecting aviator candidates for one of four helicopters prior to training day 100. ARIARDA simultaneously pursued two avenues of research. On the one hand, available test instruments were considered and evaluated for their potential to discriminate among aviators. On the other hand, groups of Subject Matter Experts (SMEs) developed criticality-rated aviator candidate abilities and traits for specific operational helicopters. Extensive literature reviews and liaison with sister services and other agencies were accomplished. Four test instruments were evaluated for use. The underlying abilities, traits, and skills these batteries purported to measure matched the abilities, traits, and skills identified as necessary by the SMEs for each of their helicopters. Upon selection of the subtests contained in the

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ARIARDA experimental test battery, high-time aviators were given the experimental battery to develop scoring profiles for specific aircraft and to generate the data for the statistical analyses that resulted in the Preliminary Multi-Track Classification Algorithm.

THE SELECTION OF AN EXPERIMENTAL TEST BATTERY FOR AVIATOR COGNITIVE, PSYCHOMOTOR ABILITIES AND PERSONAL TRAITS

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THE SELECTION OF AN EXPERIMENTAL TEST BATTERY FOR AVIATOR COGNITIVE, PSYCHOMOTOR ABILITIES AND PERSONAL TRAITS

Background

In late 1986, the U.S. Army Aviation Center (USAAVNC) redesigned the Initial Entry Rotary Wing (IERW) course of training for aviator candidates. The new training was called IERW Multi-Track (IERW MT) and became operative in May 1988. The major differences between Multi-Track and the prior IERW are: (1) In IERW the aviation candidate received primary flight training in the reciprocating engine Hughes TH-55. In IERW-MT, primary flight training is obtained in the turbine powered Bell UH-1. (2) In IERW, after completing the primary phase in the TH-55, aviation candidates completed flight training in either the UH-1 or the OH-58. Selection and training for all other aircraft occurred later. In IERW-MT, all candidates receive a common core of flight training in the UH-1 and then earn their wings in the UH-1, OH-58, AH-1 or UH-60 aircraft. The classification in IERW-MT into one of these four helicopter tracks must be made prior to training day (TD) 100, since advanced training in one of the four tracks begins on TD 101.

The research problem for the U.S. Army Research Institute Aviation R&D Activity (ARIARDA) was to develop tests and procedures for classifying aviator candidates into one of the four helicopters prior to TD 100. Discriminating measures were therefore required to assign candidates into a helicopter in which they would have the highest probability of both successfully completing flight training and also having a successful aviation career.

Since there were only eighteen months from the initial tasking to IERW-MT implementation, it was decided to simultaneously pursue two avenues of research. On one avenue, available test instruments were considered and evaluated for their potential to discriminate among aviators already highly qualified in different aircraft. On the other, groups of Subject Matter Experts (SMEs) developed a list of criticality-rated aviator candidate abilities and traits for each of the specific operational helicopters.

At the completion of both research approaches, ARIARDA united the results, linking specific tests with required aviator abilities and traits. The products of these approaches were synthesized into a test battery which could discriminate among Army aviators and provide data from which classification algorithms were derived.

Small Group Analysis

The objective of this research was to identify the skills, abilities, and traits that were essential to successful performance in specific helicopters. The Delphi techniques, originated and refined by the Rand Corporation from 1948 through 1968, are commonly used methodologies for eliciting analyses, expert opinions, and evaluations. Delphi processes have been described as characterized by methods for structuring group processes to facilitate operations on complex problems (Linstone and Turoff, 1975). ARIARDA designed three interrelated modified Delphi workshops and acted as facilitator and trainer for the workshops (Lofaro, 1986). Based on the results of those workshops, Lofaro developed a new paradigm and techniques which were used in the analysis reported here. The traditional Delphi processes were modified in the following ways:

1. Addition of formal instruction for the participants in group processes, group dynamics, and methods of consensus.

2. A guided exercise in group consensus was provided, followed by evaluation and critique of the group techniques by the participants and by the facilitator.

3. Anonymous individual ratings were combined with group discussions and group consensus in systematic steps.

4. For selected group objectives, guidance was provided to ensure the evolution of a data base in a sequential manner related to the steps taken by the group.

5. For other group objectives, group discussion and consensus were the only allowed rating methods.

Subjects. Ten subjects served in each of six workshops. A total of 60 Subject Matter Experts (SMEs), ten representing each of the six helicopter types, were involved. The SMEs were experienced Instructor Pilots or were Commissioned and Warrant Officer Advanced Course attendees. There were 22 Commissioned and 38 Warrant Officers in the sample. In addition, a separate sample of three SMEs for each helicopter type served to validate the results of the workshops.

Procedure. Six separate workshops were conducted--one for each of the aircraft of interest. The procedures for all workshops were identical. Current Aircrew Training Manuals (ATMs) for each of the aircraft were provided to the SMEs. These manuals contain descriptions of maneuvers and tasks required of aircrew members and the standards to which they must be performed for them to be considered competent aviators. Workshop participants were provided with detailed objectives and protocols for the tasks to be accomplished. The individual groups were provided printed materials specific to their helicopter, including listings of all Aircrew Training Manual (ATM) tasks for their aircraft. The tasks for each group were divided into individual, small group (5 person), and intact group (10 person) iterations for each objective. There were three major objectives for the small group analyses: (a) Identify essential tasks for each helicopter, (b) identify methods for training and performance assessment for the tasks, and (c) identify aviator traits and attributes essential to the successful and superior mission aviator. For each aircraft, two subsets of the ATM tasks were produced. One subset consisted of those tasks perceived as unique to operation of that helicopter; the other consisted of those tasks perceived as essential to operational success. The tasks in these subsets were then rated as to criticality for operational success and safety of operations. Each workshop also produced a consensual set of personal traits identified as necessary to mission success.

Analysis and Results. The lists of ATM tasks and the lists of personal traits were examined for commonality. A small group of tasks and traits were seen as essential for all aircraft, but there were substantial differences between aircraft, both in number and types of tasks included. In the case of the UH-1, however, all of the tasks and traits attributed to that aircraft were common to all of the other aircraft. The essential critical ATM tasks were categorized as to underlying abilities using Fleishman's taxonomic approach (Fleishman and Quaintance, 1984). This preliminary categorization was validated using three SMEs for each aircraft. This was accomplished by the SMEs in groups of three and individually, over a period of one week for each helicopter type. The final categorized list of critical abilities and traits is presented in Table 1.

Table 1

Comparison Of Aviator Abilities And Traits By Helicopter

Aircraft	AH-64	AH-1	OH-58	UH-1	UH-60	CH-47
Cognitive						
Time-Sharing/Divided Attention	Yes	Yes	Yes	Yes	Yes	Yes
Memory						
Long-Term	Yes	Yes		Yes	Yes	Yes
Short-Term	Yes	Yes		Yes	Yes	Yes
Decision-Making	Yes	Yes	Yes	Yes	Yes	Yes
Deductive Reasoning	Yes	Yes	Yes	Yes	Yes	Yes
Visualization	Yes	Yes	Yes	Yes	Yes	Yes
Rule Following/Information Ordering		Yes			Yes	Yes
Pattern Recognition and Detection		Yes	Yes			Yes
Oral Expression	Yes	Yes			Yes	Yes
Written Comprehension	Yes	Yes	Yes	Yes	Yes	Yes
Personal Traits						
Composure/Stress Handling	Yes					Yes
Decisiveness	Yes					Yes
Adaptability/Flexibility	Yes					Yes
Judgement/Decisions	Yes					Yes
Dedication/Determination	Yes					Yes
Aggressiveness	Yes		Yes		Yes	Yes
Team Player	Yes	Yes				Yes
Communication Skills		Yes		Yes	Yes	
Psychomotor						
Flight Control Precision	Yes	Yes	Yes	Yes	Yes	Yes
Spatial Orientation	Yes	Yes	Yes	Yes	Yes	Yes
Reaction Time		Yes	Yes	Yes		Yes
Speed of Closure		Yes	Yes	Yes		Yes
Rate of Closure			Yes		Yes	Yes
Problem Sensitivity		Yes		Yes	Yes	
Perceptual Speed		Yes		Yes	Yes	

Test Instruments

A literature search and liaison with sister services and other agencies were accomplished. In this effort, the U.S. Air Force, U.S. Navy, Federal Aviation Administration, National Aeronautics and Space Administration and the Army Research Institute became the researchers' main sources of candidate instruments. There were numerous examples of studies of the personal attributes relating to operation of various Army helicopters (ARRO, 1982; Miller, Eschenbrenner, Marco and Dohme, 1981) which, combined with recent work involving the role of attitudinal and motivational traits (Foushee and Helmreich, 1986; Helmreich, 1983; Helmreich, Foushee, Bensen and Russini, 1985), provided a basis for selection of existing test instruments for exploratory development. A bibliography of related works is included in this report. Four existing test instruments were included as candidates because of their availability and their coverage of the domains of interest. In addition, a background questionnaire eliciting biographical information, with an emphasis on flight experience, and a daily activity log, were used to ensure that subjects were not excessively fatigued nor taking prescribed medications at the time of testing.

U.S. Air Force Human Resources Laboratory Basic Abilities Test. The researchers visited the USAF Human Resources Laboratory (HRL) Brooks AFB, TX, to observe the USAF Portable Basic Abilities Test, called the Porta-BAT. The Porta-BAT was developed by the USAF and originally consisted of an interactive set of some 27 sub-tests as well as an activities interest inventory and an aircrew personality profile. Conversations with the USAF personnel involved in BAT development centered around these nine sub-tests: (a) Two Hand Coordination, (b) Complex Coordination (Stick/Throttle), (c) Decision Making Speed, (d) Word Knowledge, (e) Time Sharing, (f) Manikin, (g) Serial Mental Arithmetic, (h) Mental Rotation, 3-D, and (i) Embedded Word Test. USAF personnel had preliminary data which indicated some positive results for these BAT sub-tests. Additionally, the underlying abilities measured by these sub-tests of the BAT were seen as promising discriminators in selection and/or classification. The literature search indicated that there were some abilities which had previously been identified by Army SMEs. The researchers used these abilities as another method of selecting the BAT sub-tests. Therefore, the researchers decided to use these BAT sub-tests as part of their experimental test-battery. The USAF arranged to have one PORTA-BAT unit transported to Fort Rucker for use in the study. Descriptions of the BAT sub-tests used, as well as the underlying psychomotor, psychological and cognitive abilities tapped, are available in Siem & Carretta, 1986; Bordelon & Kantor, 1986 and Kantor & Bordelon, 1985.

U.S. Naval Aeromedical Research Laboratory Multi-Tasking Battery. The same procedure was followed with the US Navy Aerospace Medical Research Laboratory (NAMRL) at NAS Pensacola. The researchers visited NAMRL and were shown aviation selection tests that were, and are, under development there. After discussions and a reading of the available NAMRL literature, it was decided to use their most current multi-tasking psychomotor tests. The NAMRL battery consists of seven computer assisted subtests, gradually increasing in difficulty. The seven tests, increasing in difficulty are: (a) Psychomotor (PMT), Stick Only; (b) Dichotic Listening Task (DLT); (c) Dual (PMT and DLT); (d) Psychomotor (Stick and Rudder); (e) Triple (Stick, Rudder and DLT); (f) Triple (Stick, Rudder and DLT); and (g) Psychomotor (Stick, Rudder and Throttle). The Navy also provided ARIARDA with the software and the hardware to run their test battery. These tests and the necessary apparatus such as joysticks and control pedals are described in Griffin & McBride, 1986.

NASA/Helmreich Cockpit Management Attitudes Questionnaire. The next test battery selected for usage was the Cockpit Management Attitudes Questionnaire (CMAQ), developed by NASA Ames and Dr. Robert Helmreich of the University of Texas at Austin during 1983-1986. Dr. Helmreich used a cluster analysis technique to derive personal attributes and typologies from the CMAQ. The CMAQ Battery consists of the Work and Family Orientation Questionnaire, as modified by Helmreich and Spence (1978); the Revised Jenkins Attitude Survey (currently being used in USN aviator candidate selection) as modified by Pred, Helmreich and Spence (1982); The Extended Personal Attributes Questionnaire (EPAQ), as developed in Spence, Helmreich and Stapp (1974) and Spence and Helmreich (1983), and the Cockpit Management Attitudes Questionnaire developed by Helmreich (1987).

U.S. Army Research Institute Complex Cognitive Assessment Battery. The fourth, and final, test battery selected was the computerized Complex Cognitive Assessment Battery (CCAB) as developed under contract to ARI by EATON Corporation's Analytical Assessment Center. The CCAB was originally developed during 1985-1986 to ascertain the potential effect of chemical defense drugs on the performance of US Army tactical tasks, requiring high-level complex cognitive skills. ARIARDA's analyses of the sub-tests and the theoretical principles which guided their development indicated that the cognitive/psychological abilities identified were those which can also be seen as necessary for aircrew members. The CCAB is composed of the following computerized tests: (a) Tower Puzzle, (b) Following Directions, (c) Word Anagrams, (d) Logical Relations, (e) Mark Numbers, (f) Numbers and Words, (g) Information Purchase, and (h) Route Planning. A copy of the CCAB was obtained from Dr. Christine R. Hartel of ARI. A complete description of the CCAB is contained in Samet, M. G., Gerselman, R.E., Zajaczknowski, F. and Marshal-Mils, J. (1986).

Subjects. Two samples of 60 subjects each were available for testing. One of these samples was taken from high flight-time Army Instructor Pilots (IPs). For each of the six aircraft mentioned above there were ten IPs for whom that was the current primary aircraft. Each subject had a minimum of 1000 flight hours in the primary aircraft. In the case of the AH-64 aircraft, subjects with 700 - 900 flight hours were considered high-time due to the recency of fielding of that aircraft. Forty of these subjects were Warrant Officers and twenty were Commissioned Officers. They ranged in age from 26 to 47 years. The other sample consisted of 60 aviation candidates. Of these, 36 were Warrant Officer Candidates and 24 were Commissioned Officers. None of the subjects in these samples had served in the small group analyses.

Procedure. Each subject was administered the background questionnaire, the daily activity log, and all four of the experimental test instruments. The CMAQ and the background questionnaire were administered to the IPs at their first computer testing session. These instruments were administered to the aviation candidates prior to their first computer testing session. During computer testing sessions one computer unit for the BAT, and two for the CCMB were available. The number of units available for the CCAB varied from two to ten. Administration times were as follows: BAT - 3 hours; CCAB - 2 hours; CCMB - 1 hour and 15 minutes; CMAQ with background questionnaire - 45 minutes.

Analysis. Stepwise Multiple Discriminant Analysis was selected to establish distinctions among the six groups of high time aviators. The subscores from the four tests were used as candidate discriminating variables for group membership. A total of 72 subscores were used in the analysis. The stepwise procedure produced a subset of these that most efficiently discriminated among the aircraft. The resulting discriminant functions were then verified by reclassifying the IPs into groups according to the discriminant functions and observing the concordance of the assignments with actual group membership. This was done both directly and using the Jackknife procedure (removal of each subject from computation of the discriminant functions). The verified discriminant functions were then applied to the test data for the aviator candidates to assign them to aircraft.

Results. Examination of the data set revealed no indication of nonlinearity in the variables, nor were there indications of extreme skewness in the score distributions. Examination of the sample variances, however, revealed a maximum ratio of 35.34:1 for variable SDSY1 between the AH-64 and CH-47 groups. The next greatest ratio, 8.22:1 on variable LEADER, also occurred between the AH-64 and CH-47 groups. All other ratios were less than 6:1. Given the presence of very small samples and the large variance ratios, the assumption of homogeneity of variance of the variance-covariance matrices is probably not tenable.

A Stepwise Multiple Discriminant Analysis which used test battery subscores recorded from IPs to produce six aircraft groups terminated after introducing 17 of the original 72 variables in the predictor set. Although the analysis was significant [Wilk's Lambda = 0.0723, approximate $F(75, 195.8) = 1.907$, $p = 0.0002$], it failed to significantly separate groups in seven of the possible 15 two-group comparisons. The discriminant functions produced from this analysis correctly reclassified 81.67 percent of the subjects. Of the five canonical functions produced, only the first two contributed significantly to the overall analysis (combined $Chi^2(75) = 127.4$, $p = 0.0002$). These accounted for 65 percent of the total between group variance. The first function alone ($Chi^2(56) = 84.3$, $p = 0.0084$) accounted for only 38 percent of the between groups variance.

A review of the background questionnaire data for the IPs revealed that the CH-47 and AH-64 aviators typically had large enough quantities of flight time in one or more other helicopters to be considered high-time aviators in them. For example, AH-64 Instructor Pilots with 700 - 900 hours in type frequently had 2000 hours in AH-1 and 500 hours in OH-58. For IPs in the other four helicopters, flight experience was much more likely to be dominantly in a single type. Therefore it was hypothesized that the CH-47 and AH-64 IPs actually belonged to more than one group, possibly confounding the Discriminant Analysis. Given that CH-47 and AH-64 were not scheduled for immediate inclusion in the implementation of IERW-MT, these groups were removed from the data set and the Discriminant Analysis executed again.

In this case the greatest ratio of variances, 8.1:1 occurred on variable SDSY1 between the AH-1 and UH-60 groups. The next greatest ratio, 2.9:1, occurred on variable LEADER between the UH-1 and UH-60 groups. Therefore the assumption of homogeneity of variance-covariance matrices remains tentative at best. The discriminant analysis terminated with 17 variables included in the predictor set. This analysis was also significant [Wilk's Lambda = 0.0305, approximate $F(51, 60.3) = 2.6392$, $p = 0.0002$], and significantly separated groups in four of the six possible two-group comparisons. The lack of separation occurred in the comparison of the UH-1 and AH-1 groups [$F(17, 20) = 1.870$, $p = 0.0906$] and in the comparison of UH-1 and OH-58 groups [$F(17, 20) = 1.9326$, $p = 0.0799$]. The discriminant functions produced from this analysis correctly reclassified 97.50 percent of the subjects (one UH-60 pilot was incorrectly classified as a UH-1 pilot). Using the jackknife procedure to reduce the bias of reclassification resulted in a correct classification rate of 88.65 percent.

Of the three canonical functions produced, the first two contributed significantly to the analysis [Chi^2 (51) = 99.49, p = 0.0001]. These accounted for 88 percent of the total between group variance. The first function accounted for 59 percent of the between groups variance [Chi^2 (32) = 51.16, p = .0172]. The canonical correlation for the first function was 0.904, indicating approximately 82 percent of the total variance is common between aircraft group membership and the 17 predictor variables. A test for equality of the covariances of the canonical functions [M = 23.99, approximate F(18,4364.1) = 1.1256, p = 0.3189] was not significant. The standardized canonical discrimination function coefficients are listed in Table 2.

Table 2

Standardized Canonical Discriminant Function Coefficients

	Function 1	Function 2	Function 3
Tower	1.01468	0.33282	0.26663
Word Anagrams	-0.19766	-0.94064	0.71819
Mark Numbers	1.10683	0.97473	-0.51837
Numbers & Words	-1.09064	-0.19792	0.17685
Information Purchase	-0.73644	0.89444	-0.39213
Performance Composite	-1.31125	0.28699	1.05233
Cockpit Procedure & Atmosphere	0.31880	-0.79103	-0.69039
Leadership	1.20850	0.43978	0.05060
CMAQ Cluster 1	0.30109	0.19326	0.68030
CMAQ Cluster 3	-0.57643	0.28523	-0.49609
Single Dichotic Listening	-1.83953	3.74295	-2.26657
Dual Dichotic Listening	1.67248	-2.54531	2.29323
Single Tracking/ Dichotic Listening	-1.02121	-0.55952	0.28449
Dual Tracking/ Dichotic Listening	-0.85906	-1.69073	0.29334
3 Axis Tracking	0.88342	0.43572	-0.19283
Manikin	1.06659	1.36751	-0.11675
Word Knowledge	1.32751	0.01679	0.26294

The discriminant coefficients produced from this analysis are shown in Table 3. These were applied to test data taken from the sample of 60 flight students. The percentages of the student sample assigned by the discriminant functions to the four aircraft are shown in Table 4, along with the percentages of correct classification for the IPs using direct and jackknife procedures. Table 5 illustrates the coincidence of the characteristics which had been identified in the small group analyses with the behavioral constructs purported to be measured by the research battery subtests included in the discriminant functions. The included subtests have an approximately 80 percent concordance with the skills, abilities and traits identified in the small group analyses as critical to operations.

Table 3

Classification Function Coefficients

	OH-58	AH-1	UH-1	UH-60
Tower	-0.3096818E-01	-0.3842645E-01	-0.3183147E-01	-0.2629068E-01
Word Anagrams	0.8808690E-01	0.8052572E-01	0.8704776E-01	0.7074511E-01
Mark Numbers	-0.1772802	-0.1910269	-0.1822437	-0.1472893
Numbers & Words	0.9082179E-01	0.1068916	0.9764432E-01	0.8348649E-01
Information Purchase	0.7266381E-01	0.8970182E-01	0.8006078E-01	0.8091816E-01
Performance Composite	320.4010	339.7845	336.6538	319.2290
Cockpit Procedure & Atmosphere	-101.4859	-106.5237	-107.6019	-105.8042
Leadership	-63.58459	-73.44168	-65.86768	-56.67232
CMAQ Cluster 1	2.535088	2.435495	2.659146	2.627760
CMAQ Cluster 3	1.873408	2.329977	1.949866	1.944060
Single Dichotic Listening	0.4044748	0.7832269	0.5442557	0.6697529
Dual Dichotic Listening	0.6199791	0.3499966E-01	0.4710984	0.2861892
Single Tracking/ Dichotic Listening	0.9270938E-03	0.1628935E-02	0.1184953E-02	0.1653351E-03
Dual Tracking/ Dichotic Listening	0.1448790E-02	0.1328911E-02	0.1039133E-02	-0.3822131E-03
3 Axis Tracking	0.1620431E-03	-0.4047561E-03	-0.3464211E-04	0.7069260E-03
Manikin	1.843099	1.640740	1.996183	2.857444
Word Knowledge	-206.9333	-253.7745	-220.2950	-195.3552
(Constant)	-1561.797	-1703.014	-1726.109	-1616.206

Table 4

Direct and Jackknife Classifications

Direct Classification (N=40)

Actual Group	Predicted Group (Number assigned by Discriminant Analysis) OH-58	AH-1	UH-1	UH-60	Percent Correct
OH-58	11	0	0	0	100
AH-1	0	10	0	0	100
UH-1	0	0	9	0	100
UH-60	0	0	1	9	90

Jackknife Classification (N=40)

Actual Group	Predicted Group (Number assigned by Discriminant Analysis) OH-58	AH-1	UH-1	UH-60	Percent Correct
OH-58	11	0	0	0	100
AH-1	0	9	1	0	80
UH-1	0	0	8	1	89
UH-60	0	0	1	9	89
Students (% assigned)	15	19	9	57	

Table 5

Concurrence of Battery Subtests with Small Group Analyses

Sub-Test	Characteristics Measured	SGA Identified
Tower	Problem Solving/ Situational Awareness Planning	Yes
Word Anagrams	Decision Making/Pattern Recognition	Yes
	Memory	Yes
Mark Numbers	Time Sharing/Attention to Detail	Yes
	Quant. Reasoning and Analysis	No
Information Purchase	Decision Making/Attention to Detail	Yes
	Quant. Reasoning and Analysis	No
Single Axis/ Dichotic Listening	Divided Attention/Reaction Time	Yes
	Eye-Hand Coordination	Yes
Dual Axis/ Dichotic Listening	Divided Attention/Time and Resource	Yes
	Management/Reaction Time	Yes
3 Axis Tracking	Eye-Hand Coordination/Reaction Time Divided Attention	Yes
Manikin	Spatial Transformation/ Pattern Recognition	Yes
Word Knowledge	Risk-Taking/Self-Confidence General Intelligence	Yes
CMAQ Cluster 3	High: Hostility and Arrogance Verbal Aggressiveness Competitiveness Low: Positive Expressivity Communication	No
CMAQ Performance Related Composite	High: Leadership/Cockpit Procedures Cockpit Atmosphere Personal Vulnerability	Yes
CMAQ Cluster 1	High: Ineffective/Noncommunicative Low: Striving For Achievement Work Orientation/Task Mastery Goal Orientation/Independence	No
CMAQ Leadership	High: Task Delegation/Crew Coordination/Decisiveness/ Communication Skills	Yes
CMAQ Cockpit Procedure & Atmosphere	High: Communication Skills/ Differentiate Pilot vs. Crew Functions and Procedures/ Positive Expressivity	Yes
Numbers and Words	Time Sharing/Attention to Detail	Yes
	Decision Making/Pattern Recognition	Yes

Discussion

The profiles of aviators specializing in different rotary wing aircraft can be defined through the use of a broad approach test battery and there is potential for assignment of aviator candidates to an aircraft for which they most closely match this profile. This is the aircraft for which the candidate might be expected to have the highest probability of successfully completing flight training and of having a successful flight career. These inferences require validation, however, both in flight training performance and in the operational environment.

The discriminant analysis provides a set of classification formulas for the four current track helicopters which could be used by the USAAVNC in the actual student assignment process. The classification formulas constitute four linear regression equations using identical predictor variables with different sets of weights. The predictor variables include seven perceptual/cognitive subscores, five complex coordination/multi-tasking subscores, and five attitudinal/motivational subscores. These regression equations predict distances of a given subject from each of the four group centroids in multidimensional space. Each candidate then would receive four scores, one for each aircraft, which may be rank ordered to indicate the ordering of the candidate's "fitness" for each aircraft.

Several caveats need to be placed with this research. The size of the sample of high time instructor pilots used to establish the test battery discriminant functions was small, particularly in relation to the number of variables being estimated. The plan for this research called for twice this sample size, but the commitment to provide them could not be met. A cross validation of the discriminant analysis by random division of the original sample is therefore not a practical method for determining the degree of capitalization on chance for selection of variables. Validation of the predictor variable set for the discriminant functions must therefore be derived from other samples. The degree of correspondence between the purported domains measured by the test battery and the characteristics derived from the small group analyses, on the other hand, increases confidence in the predictor set. Another threat to the validity of the discriminant analysis exists in questionable multivariate homogeneity of variance. Although robustness of the procedures may be relied upon where sample sizes are large, the threat is greater in the presence of small samples. The threat to the assumption of homogeneity may be an artifact of the small sample or may indicate the presence of additional unidentified sub-populations. Again, assessment of this threat will require additional samples.

The classification of aviation candidates into four different helicopters at an extremely early phase of their training, after less than 100 days of ground and flight training, posed a difficult research problem for ARIARDA. Not only was there no successful analog available to base the research upon but also the classical approach of predicting individual grades, class standing, or overall grade averages was not expected to discriminate among groups of successful aviators or aviation candidates. The extensive literature reviews and liaisons with other agencies indicated that an operational classification algorithm was obtainable only if distinctive profiles of high-time, successful pilots in different helicopters could be obtained, and if aviation candidates could be matched to these profiles. This has been accomplished, within a restricted time frame, using readily available instruments, and at a minimal cost.

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