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**THE UNIQUE CONTRIBUTION OF
SELECTED PERSONALITY TESTS TO
THE PREDICTION OF SUCCESS IN
NAVAL PILOT TRAINING**

D. R. Street, Jr., K. T. Helton, and D. L. Dolgin

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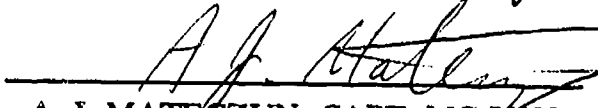
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13. ABSTRACT (Maximum 200 words) This study concerns the relationship of naval flight training performance to scores on the Aviation Qualification Test/Flight Aptitude Rating (AQT/FAR) and the automated Pilot Personality Questionnaire (PPQ). We analyzed a sample of 211 pilot candidates who had taken the AQT/FAR and PPQ. We found that the PPQ competitiveness scale and three of the AQT/FAR subtest score means were significantly different ($p < .05$) for those who passed ($N = 168$) and those who attrited ($N = 43$) flight training. Discriminant analysis yielded a linear composite of the AQT/FAR and PPQ subtest variables that could be used to classify the students according to the likelihood of passing or attriting during flight training. The resulting discriminant function explained 9% of the variance in the pass/attrite criterion ($r = .30$). We found that a 50% reduction in attritions could be attained with a 23% increase in false rejections. The regression analysis was significant ($p < .01$) and indicated that three scales of the PPQ and the AQT and FAR scores accounted for unique variance in a linear prediction equation. The FAR and PPQ competitiveness scale were the most powerful predictors of overall flight training success.				
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SUMMARY PAGE

THE PROBLEM

Current naval aircrew selection research typically focuses on psychomotor and cognitive abilities, but evidence from flight training attrition studies suggests that many failures may be due to personality/motivational factors. This study concerns the relationship found between the elements of primary, intermediate, and advanced naval flight training performance, the Aviation Qualification Test/Flight Aptitude Rating (AQT/FAR), and the results of an automated personality assessment instrument, the Pilot Personality Questionnaire (PPQ). The value of personality testing to naval aviation selection is discussed.

FINDINGS

We employed discriminant analysis to find a linear composite of the AQT/FAR and PPQ subtest variables that could be used to classify the students into pass/attrite categories during flight training. The stepwise discriminant function identified the AQT, FAR and PPQ Competitiveness variables as adding significant variance to the pass/fail prediction equation. The results of the stepwise discriminant function also indicated that the PPQ Competitiveness scale accounted for variance not otherwise accounted for by AQT/FAR scores. A standard discriminant function was then conducted to determine the amount of variance accounted for by each of the AQT, FAR, and PPQ Competitiveness variables identified in the stepwise discriminant function. We found that attrition could be reduced 50% with a 23% increase in false rejections based on the discriminant analysis. The FAR and PPQ Competitiveness scale were the most powerful predictors of overall flight training success.

RECOMMENDATIONS

Although exploratory in nature, we believe that our findings demonstrate the value of the PPQ Competitiveness scale as a predictor of aviation training success. Future cross-validation studies with the discriminant model described in this report are necessary to establish the ultimate value of the PPQ Competitiveness scale in predicting flight training success.

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INTRODUCTION

The search for the ideal aircrew selection test battery is not a recent phenomenon. For nearly a century, psychologists have been theorizing about creating scales to measure the variety of attributes and qualities that comprise the successful pilot (1). Research into the ideal aviation selection test battery can be found in the archives of naval research dating back to the first World War. The components of many of the early batteries are remarkably similar to those currently used by the U.S. Army, Navy, and Air Force as well as other nations. The ultimate goal of this research has been to find valid and reliable predictors of success in flight training.

The present paper deals with an automated personality assessment, the Pilot Personality Questionnaire (PPQ). The PPQ is an attribute self-report inventory. It was designed to take advantage of those useful assessment elements found in various paper-and-pencil tests that have historically shown promise in tapping specific aviation-linked personality characteristics. The PPQ was compared to a pass/fail criterion by Shull and Dolgin (2). In that study, subjects' PPQ scores were compared to primary flight training outcome. They found a marginally significant relationship between various PPQ scores and the pass/fail criterion in primary flight training. Other researchers have considered personality factors with varying degrees of success (3).

At the end of WWI, naval aviation research identified five major dimensions of the successful aviator (4). First, the aviator must be able to remain cool under stress. Second, the aviator must be able to consistently make the correct decision at the critical moment. Third, the aviator must display physical and mental alertness when needed. Fourth, the aviator must display a love of aviation, and fifth, the aviator must demonstrate persistence in the ambition toward success in aviation. Additional attributes identified as critical to the successful aviator were general intelligence, good muscular coordination, a keen sense of equilibrium, and an awareness of distance and velocity.

These qualities have been reiterated in numerous articles and technical documents for both the military and civilian aviator and remain essentially unchanged in modern selection research (e.g., 1). Recent research within civilian and military aviation has identified five major quality and skill domains that may be useful in predicting aviator performance (3); namely, psychomotor coordination, background information, information processing, general cognitive ability, and personality traits. The actual assessment strategies used in military and civilian aviation today may differ, although the domains remain notably similar. A primary goal of the psychological researcher in aviation research has been to create tests that assess those basic skills and attributes in order to improve selection decisions.

Traditionally, the scores on these tests are compared to future flight training performance to identify the relative importance of each dimension in some prediction equation. The general purpose is to formulate a prediction system that captures the greatest number of potential successful aviators while minimizing training failures. The amount of variance explained by each domain is normally significant although usually small on an absolute basis (less than 9%). However, the explained variance of training success when these various domains are combined in the prediction equation can increase the likelihood of a correct selection decision (5). Ultimately, the utility of these prediction equations depends heavily on the economic consequences of a wrong selection decision (6).

The traditional testing domains in aviation selection research include psychomotor coordination, background, information processing, general cognitive ability, and personality. Psychomotor coordination has historically been the most robust area of testing for success in actual flight training. Psychomotor strategies typically focus on eye-hand-foot coordination in their simplest forms, although more sophisticated and promising strategies combine such skill with problem solving and reaction time in an aircrew like

environment (6). The relative importance of psychomotor coordination has been evidenced in a variety of studies (1).

Background has a long-standing history of use in civilian job selection and aviation selection research (7). Morrison (8) reported that the Biographical Inventory (BI) used by the Navy has been repeatedly cited as accounting for unique variance in the academic and flight performance of pilot training. The BI also taps so-called "officer-like" qualities. Theoretically, biographical measures reflect what a person has done in the past. Street and Dolgin (7) concluded from a review of the literature that this is the best predictor of what a person will do in the future. Thus, strategies that measure a person's knowledge of aviation and interest in flight are attempts at predicting the individual's ultimate interest in aviation. Presumably, the greater a person's interest, the greater the likelihood that individual will continue with an aviation goal. Background assessment methods such as biographical inventories have explained slightly less overall predictive variance than psychomotor measures (1). They are easily administered and relatively immune to faking when the questions are anchored to actual experiences rather than general likes or dislikes. The BI has been demonstrated to improve the accuracy of predictions regarding attrition in naval preflight training (7).

Information processing falls third behind psychomotor coordination and background in the amount of variance accounted for in prediction equations. Measures of this aspect typically focus on the speed and efficiency with which an individual is able to make decisions about sensory qualities in an aircrew environment. Information processing measures have been studied in air-traffic controllers (9). Analogies in operating complex Navy aircraft can be seen in target acquisition tasks, display monitoring, flight equilibrium awareness, as well as crew coordination and radio monitoring. Only recently have strategies in this area attempted to combine all these activities in a simultaneous presentation similar to the cockpit environment. Examples of information processing tests include the Complex Visual Task (8), the U.S. Air Force Basic Attribute Tests (10), and others (11,12).

General cognitive ability has proven to be of somewhat more limited value than the above three domains in aviator selection research (3). Cognitive ability is usually defined operationally by standard aptitude or intelligence tests. For example, the Navy Academic Qualification Test (AQT) is a general intelligence test that taps academic abilities related to those found in preflight and flight training. The Flight Aptitude Rating (FAR) includes the Mechanical Comprehension Test (MCT) and Spatial Apperception Test (SAT) and is an aptitude-related measure. A minimum level of general intelligence is required, although certain unique cognitive skills become apparent in the successful aviator. Given this distinction, the AQT is more a measure of general ability, and the FAR a measure of unique aviation related skills. The AQT/FAR continues to be the primary nonmedical tool in naval aviation selection.

Personality, the focus of our investigation, has proven to be the least robust of the five major aircrew assessment dimensions (3,13). Historically, researchers have tried to find the ideal aviator profile among numerous personality measures. This ideal aviator personality profile has often been called "the right stuff." Promising results have been found in identifying characteristics that improve the likelihood of later success in aviation such as persistence, motivation, coolness under pressure (clear thinking), and novel problem solving (e.g., 14).

Personality testing has improved with tools that assess specific attributes as opposed to the general approach of most personality measures, which are composed of numerous questions and whose responses are then analyzed in search of trends. One recent study (15) utilized a measure designed to assess 31 behavioral traits commonly found in working environments. That study focused on experienced Army aviators and found significant differences between nonaviators and aviators on 22 of 31 administered subtests of the Occupational Personality Questionnaire. The emergence of increasingly effective personality measures has prompted the Air Force to reconsider personality testing (16). Ongoing research at the Naval Aerospace Medical Research Laboratory (NAMRL) has generated data on a variety of personality measures including

validation of a "risk test" with recommendations for naval aviation implementation. However, the Navy does not currently have an operational personality measure in pilot selection.

The high cost of training aircrew to operate modern naval aircraft with a simultaneous decline in retention rate for these same trained aircrew, increases the importance of utilizing the best selection methods available. This importance is underscored by the fact that every aircrew selectee who fails to complete training contributes to a potential operational personnel shortage if expected replacements necessary to maintain military readiness do not materialize as planned. As previously mentioned, research to date has generally focused on the testing of various psychomotor and cognitive abilities (10,13,17). While these abilities would seem logically necessary for successful performance in flight training and beyond, failures may be due, at least in part, to personality and/or motivational factors (18).

Certain personality characteristics or traits may correlate highly with success in initial/primary flight training and beyond. For example, interpersonal orientation, self-assertiveness, and achievement motivation are associated with pilot attitude and performance (19). Important developments in personality assessment have included attempts to avoid response bias by masking the personality dimension of interest and to screen for positive attributes, in contrast to a past emphasis on psychopathology (15).

The present study investigates the value of personality, as measured by the PPQ, in the prediction of flight training success. An earlier study (2) found a relationship between the PPQ and primary flight training. Our investigation differs from that study (2) in that we used a larger comparison sample and examined test scores on the current U.S. Navy/Marine Corps aviation selection test battery, the AQT/FAR, in relation to the PPQ. We also compared scores on the PPQ and AQT/FAR to performance in naval intermediate and advanced flight training.

METHODS

SUBJECTS

The subjects who participated in this study had taken the AQT/FAR prior to selection for aviation training. Each of the subjects took the PPQ at NAMRL between 1989 and 1991 as part of a continuing selection research project. The subjects participated in the study on a voluntary basis. Before administering the test, all subjects were informed that the test results obtained would not affect their status in the flight program and would not be entered into their service record.

The data pool consisted of 245 subject PPQ and AQT/FAR cases collected while the subjects were waiting to enter primary flight training. From this subject data pool, only the data from subjects who later passed through advanced flight training or attrited due to academic- or flight-related failures in any flight training phase were included in the analysis. Subjects who had attrited flight training due to nonflight- or nonacademic-related failure were not included in the analysis. The resulting pool consisted of 201 males and 10 females ranging in age from 21 to 29 years ($M = 22.77$, $SD = 1.36$). The sample was further divided into two groups for analysis: those who had passed ($N = 168$) and those who had failed ($N = 45$) during any phase of flight training.

APPARATUS

The PPQ was administered as part of a 3-4 h assessment battery. The first 94 subjects were given the test on an Apple IIe microcomputer system with an Amdek Color Plus I monitor. The remaining 141 subjects were administered the test on a Zenith 248 with a Zenith monochrome monitor. Response entry on both systems was via a numeric keypad.

MATERIALS

PPQ

The PPQ is a self-administered, untimed, personality inventory containing 112 multiple-choice items responded to via a computer keyboard. The test is a combination of four different personality tests: 1) Locus of Control (LOC), 2) Work and Family Orientation (WOFO), 3) Personality Attributes Questionnaire (PAQ), and 4) Social Desirability Scale (SDS). These four tests were included because of their prior use as pilot personality measures.

The LOC (20) was designed to measure an individual's attribution or cause and control of life events. The scale separates causal attribution as being either self-controlled (internal) or controlled by others (external). The WOFO (21) is a measure of achievement motivation and attitudes toward family and career. The PAQ (22) measures socially undesirable behaviors such as hostility and aggressiveness. The SDS (23) was included as a measure of motivation and as a way of reducing response bias by measuring self-report distortion.

Subjects' responses were partitioned into 12 scales that were designed to measure (1) self-assertiveness, (2) interpersonal orientation, (3) aggressiveness, (4) hostility, (5) verbal aggressiveness, (6) submissiveness, (7) high-mastery motivation, (8) high-work motivation, (9) competitiveness, (10) self-control, (11) fatalism, or (12) high-social desirability. (See Dolgin and Gibb (13) for a discussion).

AQT/FAR

The AQT/FAR, which contains four multiple-choice tests, is the primary nonmedical instrument that the U. S. Navy/Marine Corps uses to screen officer flight training applicants. The Academic Qualification Test (AQT) is a single test that measures such attributes as general intelligence, verbal and quantitative abilities, clerical skills, and situational judgement. The FAR is made up of three different tests. The Mechanical Comprehension Test (MCT) assesses mechanical aptitude and the ability to perceive physical relationships. The Spatial Apperception Test (SAT) is a measure of spatial orientation that involves determining the angle of bank at which various aircraft are configured. The BI samples personality history, interests, and attitudes while assessing acquired aviation knowledge; it is the only untimed test of the group. In this research, only the raw AQT/FAR scores, not the stanine scores, were used for analysis.

DESIGN

We separated the subjects into a pass or attrite group based on their performance during all stages of flight training. Subjects were considered to have attrited if they failed any phase of flight training due to academic- or flight-related difficulties. Next, we compared the PPQ scale score and AQT/FAR subtest score means for the pass and attrite groups. Student's *t* tests were conducted for the pass and attrite groups to explore simple group mean differences. We then conducted a series of multivariate analyses to assess the predictive value of group subtest differences. Discriminant analysis was appropriate for this task and was used to further describe the multivariate relationships in the data. The PPQ and AQT/FAR scores were first entered into a forward stepwise discriminant function analysis based on the pass/attrite criterion in to reduce the set of variables to the smallest number of predictor variables with maximal prediction of the criterion. In this procedure, variables with the highest relationship with the criterion were added to a regression equation. The partial correlations were used to indicate the degree of relationship. As variables were added, the multiple correlation was recomputed. When the changes in *R* at each step were no longer significant, variables were no longer added. A priori, we also decided to retain at least the AQT and FAR as well as any other variable that significantly added to a prediction equation. At this point, the prediction equation included only those variables predictive of the pass/fail criterion. The variables remaining in the

equation after stepwise discriminant analysis were then entered into a standard discriminant analysis to determine a classification model.

RESULTS

Means and standard deviations for the pass and attrite groups are presented in Table 1. We analyzed the group means to determine possible differences. These results are also presented in Table 1.

Table 1. Means and Standard Deviations (SD) for Pass and Attrite.

Variable	Pass (N = 168)		Attrite (N = 43)	
	Mean	SD	Mean	SD
Pilot Personality Questionnaire				
Self-assertion	26.88	3.01	25.95	3.15
Interpersonal orientation	21.95	4.09	22.44	4.80
Aggression	19.74	3.39	19.37	3.81
Hostility	13.76	4.46	12.98	4.74
Verbal aggression	4.30	2.66	4.79	2.77
Submissiveness	5.42	2.66	5.28	2.29
Mastery motivation	22.96	4.03	22.40	3.72
Work motivation	22.21	2.04	22.16	3.50
Competitiveness	16.05	2.62	14.63	4.04 ***
Self-control	21.67	4.16	22.42	4.26
Fatalism	15.51	8.09	15.21	6.26
Social desirability	75.96	14.91	78.01	13.33
Aviation Selection Test Battery				
AQT	5.79	1.19	5.37	1.16 *
FAR	7.13	1.70	6.35	1.78 **
SAT	23.45	4.29	21.86	5.38 *
MCT	50.73	7.93	47.58	8.30 *
BI	41.79	11.52	38.65	9.10

* $p < .05$

** $p < .01$

*** $p < .005$ (two-tailed)

The results of t tests for independent samples are also presented in Table 1 for the pass and attrite groups during overall flight training (i.e., primary, intermediate, and advanced). The group means for the AQT, MCT, and SAT scores were significantly different at the $p < .05$ level, while the group means for the FAR (a linear composite of the SAT, MCT, and BI) and the Competitiveness scale were significantly different at the $p < .01$ level. This procedure was employed by Picano (15) to describe differences between experienced Army pilots and a nonaviation standardization sample of the Occupational Personality Questionnaire. As mentioned, the simultaneous application of 17 separate t -tests resulted in an increased probability of significance through chance. The probabilities were not adjusted to account for this because

we employed multivariate techniques to assess the value of differences in the prediction of flight training success.

To assess the contribution of the various PPQ and AQT/FAR variables to a linear prediction equation, we conducted a stepwise discriminant function. Five variables met the tolerance (.01) requirements for independence and remained in the equation. These were the AQT, FAR, Verbal Aggression, Competitiveness, and Self-Control scales of the PPQ. The variance accounted for by the 12 remaining AQT/FAR and PPQ variables not included in the equation was accounted for by those retained in the equation. Although five variables met the tolerance test for independence, only the PPQ Competitiveness scale met our a priori requirement and added significant variance to the prediction equation. This was also the only PPQ variable to be significantly different in the comparison of the pass/fail group means. The MCT, SAT, and BI did not meet the redundancy test and were dropped from the analysis. This was not surprising, since the FAR is a composite of these subtests.

The three significant variables remaining in the equation after stepwise discriminant analysis were next entered into a standard discriminant analysis. For precision purposes, Table 2 presents the F 's to Remove and Wilk's lambda values produced in the standard discriminant analysis with five predictors retained. The F 's to Remove show the relative weights of the scales in the equation. Summary statistics for the standard discriminant function include Wilk's lambda equal to .92194 and an approximated $F(3, 207)$ of 5.84 ($p < .0007$).

Table 2. Summary Statistics for Standard Discriminant Function Analysis.

Variable	Wilk's lambda	Partial lambda	F to remove	p -level
Competitiveness	.952380	.968045	6.833145	.0096
FAR	.944001	.976637	4.951822	.0271
AQT	.936931	.984007	3.364370	.0681

A classification equation was developed for use with the unstandardized raw scores remaining in the equation after stepwise analysis. The classification model with the variable weights and constant are presented in Table 3. The unstandardized roots presented in Table 3 can be used with raw values as the basis for future cross-validation studies with a new sample. The actual discriminant cutoff score and/or prior probabilities of membership in the two groups may be adjusted to explore effects on pass and attrition rates.

Table 3. Discriminant Function Classification Roots for Unstandardized and Standardized Scores.

Variable	Unstandardized Root	Standardized Root
AQT	.3843	.4545
FAR	.3210	.5505
Competitiveness	.2167	.6417
Constant	-7.8448	

Table 4 presents the discriminant function classification matrix with the five AQT/FAR and PPQ variables remaining in the equation. Pass and attrite means were significantly different for the distribution of discriminant function scores calculated for the two groups ($\chi^2 (3) = 16.86, p < .001$). A Pearson correlation coefficient of .28 was obtained. The discriminant function explained 7.7% of the total variance. The discriminant function was able to accurately classify 70.1% of the cases. To reduce attrition by 50%, the prior probabilities were adjusted to 57% and 43% for the pass and attrite groups. This level of attrition reduction was obtained at a cost of 41 out of the 168 (24%) student naval aviators who would have otherwise passed through advanced flight training.

Table 4. Classification Matrix. *

Actual Group	Predicted Group Membership		Cases
	Pass	Attrite	
Pass	127 75.6%	41 24.4%	168
Attrite	22 48.8%	21 51.2%	43

* Percent of grouped cases correctly classified: 70.1%

DISCUSSION

Using the PPQ, we found that the competitiveness personality trait in successful student naval aviators was significantly different from students who attrite. This difference coincided with differences found on the naval aviation selection test battery for the same groups. Furthermore, student naval aviators who passed through advanced flight training were also more likely to score higher on the MCT and SAT subtests of the AQT/FAR. In other words, increases in MCT and SAT scores appear to be related to an increased probability of success in flight training. However, there was no difference in their BI scores of the FAR.

We also found that pass and attrite students were statistically different on competitiveness as measured by the PPQ. This difference was greater than that found on any AQT/FAR variable. These results are consistent with those of previous researchers (14,15) and indicate that those successful aviators in our study were different on some personality characteristics from their unsuccessful peers.

Beyond the presence of mere differences in the two groups on various personality and cognitive variables, we believe that the groups are sufficiently different to make future distinctions possible. This had not been done by Picano (15) or Shull and Dolgin (2) who had described differences in the samples and had not established a prediction model based on the difference.

The practical value of the differences obtained in our study was suggested through discriminant analysis and reveals that the PPQ may increase the accuracy of decisions regarding likelihood of succeeding through advanced flight training. The contribution of the PPQ to the existing AQT/FAR predictors in our prediction equation is statistically significant. In fact, the PPQ competitiveness scale explained the greatest amount of variance in the final prediction equation. Taken as a whole, the results describe a picture of the successful naval aviator based on high general cognitive ability (AQT), high spatial reasoning (SAT), high mechanical reasoning (MCT), and high competitiveness (PPQ). There is a related cost in terms of false rejections who would have otherwise passed through advanced flight training. A decision to implement a system including the PPQ should weigh the cost of lost aviators against the savings gained through reduced attritions. We believe that the PPQ deserves increased attention as a predictor of pilot training success.

RECOMMENDATIONS

Although exploratory in nature, we believe that our findings demonstrate the value of the PPQ Competitiveness scale as a predictor of aviation training success. Future cross-validation studies with the discriminant model described in this report are necessary to establish the ultimate value of the PPQ Competitiveness scale in predicting flight training success.

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