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Studies of Poststrike Air Traffic Control Specialist Trainees: III. Changes in Demographic Characteristics of Academy Entrants and Biodemographic Predictors of Success in Air Traffic Controller Selection and Academy Screening

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16. Abstract

A Biographical Questionnaire (BQ) was completed by 3,578 air traffic control students who entered the FAA Academy between October 1985 and September 1987. The demographic characteristics of these more recent Academy trainees (from a more stabilized poststrike selection process) were compared with two previous groups of Academy entrants. The impact of biodemographic characteristics on success in ATCS training was evaluated for all entrants, and then for gender and minority status subgroups. Also, results were obtained from the aptitude tests that were used to select the Academy entrants. Pooled within-groups correlations between the discriminating variables and the canonical discriminant function were calculated to determine the characteristics related to Academy pass/fail status.

Some of the variables that were significantly related to Academy performance included high school math grades, personal performance expectations, age, and the number of times an ATCS applicant had taken the qualifying aptitude tests. The most consistent and important predictor of success was the average grade in high school mathematics courses, while other predictors had varying significance depending on the demographic subgroup. While the age of Academy students (despite the age-30 limitation) bears a strong and consistent relationship to Academy success, other biodemographic factors can be used to improve recruitment and selection of ATCSs.

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STUDIES OF POSTSTRIKE AIR TRAFFIC CONTROL SPECIALIST TRAINEES: III. CHANGES IN DEMOGRAPHIC CHARACTERISTICS OF ACADEMY ENTRANTS AND BIODEMOGRAPHIC PREDICTORS OF SUCCESS IN AIR TRAFFIC CONTROLLER SELECTION AND ACADEMY SCREENING.

INTRODUCTION.

Applicants for the job of Air Traffic Control Specialist (ATCS) undergo a two-step selection process. They must first pass a battery of written selection tests, pass medical and security examinations, and complete an interview prior to employment. Those hired are then required to complete successfully a nonradar screening program, the second stage of the selection process, which takes place at the FAA Academy in Oklahoma City. In the screen, students receive instruction about air traffic control principles and procedures. Their aptitude for the ATCS occupation is then evaluated based on performance on paper-and-pencil tests and their ability to apply ATC procedures in laboratory simulation problems. Students who pass the screening program are classified as "developmentals" and are required to continue in successive phases of classroom, simulation, and on-the-job training at their assigned air traffic control facility.

Since 1976, the focus of the Academy screen has been on identifying those entrants who have the potential for completing all the training requirements necessary for becoming full performance level (FPL) ATCSs. Between January 1976 and September 1985, separate programs existed for the en route and terminal options. During that period, only minor programmatic changes were made to the screen, primarily involving the implementation of revised versions of the tests and laboratory problems. A major change was made in October 1985, when the programs used to screen ATCSs for entry into the terminal and en route options were combined into a "common screen." The percentage of entrants passing the "common screen" was nearly equivalent to the combined percentage that had previously passed the separate en route and terminal programs (8). The Academy screening program has been, and continues to be, monitored and evaluated by psychologists at the FAA Civil Aeromedical Institute (CAMI) to ensure standardization and to assess program validity.

A demographic comparison of Air Traffic Control Specialists at the FAA Academy, both prior to and immediately following the October 1981 firing of striking controllers, showed some significant changes in the characteristics of Academy trainees (4). For example, when comparing prestrike trainees with those who entered the Academy during the 20 months that immediately followed the strike, differences of considerable magnitude were found in prior experience, veteran status, minority representation, and educational level. Specifically, the following demographic changes occurred from prestrike to poststrike: the proportion of trainees reporting prior ATC experience dropped from 50% to 15%, the percentage of trainees with veteran's preference points declined from 60% to 31%, minority group members decreased from 13% to 7% of Academy entrants, while the proportion of trainees who had graduated from college increased from 38% to 48%.

That research (4) and other studies (1,12,14) have indicated that several biographical variables, such as high school grades, self-assessment of performance potential, and the trainee's age, were predictive of FAA Academy success. The age of the trainee at the time of entry into the Academy has been shown (beginning in 1961) to be inversely related to various measures of success in Academy training/screening programs (3). Beginning in 1972, an age limit of 30 years was established for trainees in the en route and terminal ATCS options. Despite this age restriction, Collins, Manning, and Taylor (4) found that, for a sample of immediate-poststrike Academy entrants, multiple regression analyses ranked the trainee's age as a) the most important biographical predictor of Academy performance for minority group members, and b) the second most important predictor (after high school grades in mathematics courses) for nonminority students.

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The present study was conducted to compare the characteristics of more recent Academy entrants (from a more stabilized, poststrike selection process) with those of the prestrike and immediate-poststrike groups previously reported. The circumstances surrounding the hiring of replacements for the fired controllers were unusual: there was a great deal of national publicity based on news accounts of the strike, the national job market was weak at that time, and the publicized salaries of the former ATCS work force had considerable appeal to applicants. For these reasons, it was likely that those ATCSs hired soon after the strike could have demographic characteristics different than those hired several years later.

The use of biographical data as predictors of job performance requires a periodic review to determine if there has been a reduction in the validity of the items (6). Thus, a second purpose for the present study was to select a more recent sample of Academy entrants to evaluate the impact of biodemographic characteristics on success in the Academy screen for all entrants, and then for women and minority groups. Some of the issues that were selected for review included: a) assessing potential changes in predictive validity over time, b) determining the development of any significant, new biographical correlates with Academy success in the "common screen," and c) examining the interrelationships between biographical data and the aptitude test scores used in the selection of ATCS applicants.

Method.

A Biographical Questionnaire (BQ) was given to all ATCS students who entered the FAA Academy "common screen" between October 1985 and September 1987. The BQ, completed on a voluntary basis during the first days of Academy orientation, contained 145 multiple-choice items that addressed several areas of the entrant's background and career expectations. Since 1977, various forms of the BQ have been given, with several of the items taken from Owens' Biographical Questionnaire (10). Many of the items in the BQ administered for this study were identical to items used in previous studies (4,12), while some items had been revised and others added for the first time.

Educational background was addressed on the BQ with items regarding grades received in high school courses (mathematics, physical science, and English), years of college completed, degrees received, grade point averages, college hours earned in various subject areas, and aviation coursework completed at technical schools or colleges. Information was obtained about any prior military or civilian experience in air traffic-related work, including amount of experience and type of facility. Also, the students were asked to indicate which aviation ratings/licenses they had ever received. A series of items requested the trainees to rate the importance of various factors (such as salary, benefits, job security, intellectual challenge, opportunity to benefit others, and interest in aviation) that may have influenced their occupational choice. The BQ contained two questions requesting self-evaluation of the amount of time that the respondent anticipated it would take to become effective as an ATCS, and the level of personal performance the student expected to achieve compared with other air traffic controllers. Another section of the BQ measured commitment to an ATCS career, attitudes regarding work-related issues such as rotating work schedules and increased automation, the importance of becoming a manager or supervisor, and the extent of expected satisfaction with several aspects of their ATCS career. Also, general information was requested regarding marital status, socioeconomic background when growing up, whether left or right handed, and alcohol and tobacco usage.

Scores were obtained for the Office of Personnel Management (OPM) aptitude tests used to select the Academy entrants. The OPM test data included scores for the Multiplex Controller Aptitude Test (MCAT), Abstract Reasoning Test (ABSR), Transmuted Composite (TMC; a weighted formulation of the MCAT and ABSR), and the Occupational Knowledge Test (OKT). The MCAT is a paper-and-pencil test with multiple-choice type items that was developed to measure an applicant's ability to identify potential conflicts between aircraft, compute time-and-distance relationships, and interpret general information. The ABSR assesses the ability to determine interrelationships among sets of figures and letters. The OKT was designed to determine the applicant's knowledge (based on prior experience) of air traffic

control regulations and procedures, navigation, aviation weather, etc. Previous research (5,11) suggested that the MCAT measures both perceptual abilities and cognitive reasoning, while the ABSR is related only to a perceptual ability factor.

The entrant's gender, minority group membership, and age at the time of entry into the FAA Academy were obtained from the FAA's Consolidated Personnel Management Information System (CPMIS).

The criterion measures for this study were a) whether the student passed or did not pass the Academy program and b) the trainee's final Academy score. Entrants who did not pass included both those who had a failing final score and those who withdrew before completion of the program. Final Academy scores are not given to trainees who withdraw.

RESULTS AND DISCUSSION.

Demographic Characteristics of Academy Entrants.

Table 1 shows the comparison of demographic characteristics of Academy trainees involving three groups: a sample of 6,059 who entered the Academy before September 1981 (prestrike), 8,159 who entered between September 1981 and April 1983 (immediate-poststrike), and 4,278 recent-poststrike entrants who completed the latest version of the BQ between October 1985 and September 1987. The average age of Academy trainees declined slightly over the three time periods. The percentages of women during the two poststrike periods were stable at 15%, but slightly below the prestrike level of 17%. The proportion of trainees who were college graduates had increased from 38% to 48% from prestrike to immediate-poststrike. That proportion declined to 45% among the recent entrants, while the percentage of ATCS students with only high school diplomas increased among recent entrants to approximately the prestrike level. Similarly, the proportion of recent minority trainees improved from the immediate-poststrike level (7% to 9%) but remained below the prestrike level.

TABLE 1. COMPARISON OF DEMOGRAPHICS OF FAA ACADEMY ENTRANTS

	Prestrike 1976-1981 (N= 6,059)	Immediate Poststrike 1981-1983 (N= 8,159)	Recent Poststrike 1985-1987 (N= 4,278)	
Average age	26.5	26.3	25.9	Years
Sex	83	85	85	% Males
	17	15	15	% Females
Education level	14	9	13	% High school only
	48	44	42	% Some college
	38	48	45	% College degree
Minority group	13	7	9	% Minority
	87	93	91	% Nonminority
Prior experience	30	68	69	% No prior experience
	20	17	10	% Aviation exper. only
	50	15	21	% Prior ATC experience

Overall, more than two-thirds of both poststrike samples reported neither prior aviation nor prior air traffic control experience, whereas over two-thirds of prestrike ATCS trainees had such prior experience. The 21% of recent entrants reporting prior air traffic control experience (as indicated by IFR or VFR operations experience) was above the immediate poststrike level (15%) but still significantly lower than the prestrike group. The aviation experience category, which included trainees with a pilot rating, instructor rating, or with

military experience in an aviation-related job, contained fewer recent-poststrike students than did either the prestrike or immediate-poststrike groups.

Biographical Questionnaire Items and Academy Performance.

Several analyses were conducted to determine the biographical factors that were important in predicting Academy success or failure/withdrawal in the Academy screening program for only the sample of recent-poststrike Academy entrants. Then, the factors significantly related to performance for female and minority groups were examined. For all of the analyses relating biographical factors to Academy performance, the sample was restricted to exclude readmitted entrants who had previously failed or withdrawn from the Academy ("recycles"), and those who were missing OPM test data because they had been selected through "special hire" programs. The total sample of 3,578 included 474 women and 215 minority group members who entered between October 1985 and September 1987.

The statistical procedures and analyses described in this report were performed using the computer software, SPSS-X: Statistical Package for the Social Sciences (9).

Total Sample of Recent Academy Entrants.

Table 2 lists the BQ items that were significantly correlated (Spearman coefficients $p \leq .001$ and Chi-square $p \leq .01$) with the Academy success criterion of pass/not pass. The categories of significant items identified basically confirmed previous findings (4,12). In particular, high school grades (in mathematics and physical science courses, and the overall grade point average), prior IFR operations experience as an ATC in the military, self-evaluation of future performance, and the number of times the entrant took the OPM selection tests continued to be predictive of Academy performance.

TABLE 2. BQ ITEMS CORRELATED WITH FAA ACADEMY SUCCESS CRITERION - OVERALL SAMPLE (Sorted by Size of Correlation with Pass/Not Pass)

	Correlation* with Pass/not pass
Educational background	
1. Higher mathematics grades in high school	.19
2. Higher overall high school G.P.A.	.11
3. Higher college G.P.A. (if a college graduate)	.09
4. Higher physical science grades in high school	.07
5. 13 or more credit hours in math courses in college	.06
Work experience	
1. Air traffic control experience in military (IFR operations)	.08
2. Worked in ATC-related job in military	.08
Self-assessment of future performance as an ATCS	
1. Less time will be required to become effective as an ATCS	.14
2. Expected performance level will be in top 10% of all ATCSs.	.13
3. Will not be difficult adjusting to rotating work schedule	.08
Other items	
1. Number of times OPM tests were taken prior to being hired	-.14
2. Benefits of "very great importance" in choice of ATC occupation	-.07
3. Often talks to friend/co-worker/family member when tense	-.07
4. Often engages in yoga, meditation, etc. when tense	-.07
5. Grew up in a city of 500 thousand people or more	-.06

* Spearman correlation coefficients $p \leq .001$

Two of these BQ items namely, a) the college grade point average and b) the number of credit hours in mathematics courses, were applicable only to the entrants who had attended college.

Table 3 presents the matrix of intercorrelations of the significant BQ items (minus the two described above) for the entrants with valid (nonmissing) responses to all items.

TABLE 3. INTERCORRELATIONS OF SIGNIFICANT BQ ITEMS

A	--												
B	57*	--											
C	41*	56*	--										
D	-17*	-13*	-12*	--									
E	-20*	-15*	-14*	89*	--								
F	08*	06*	10*	18*	18*	--							
G	10*	08*	12*	09*	08*	43*	--						
H	-03	-06*	-06*	24*	27*	13*	12*	--					
I	-16*	-14*	-10*	10*	11*	-04	-02	04	--				
J	02	01	01	00	01	01	03	00	-02	--			
K	-02	-03	-04	03	03	02	05	04	05	12*	--		
L	00	05	07*	-04	-05	-01	03	-06*	01	-01	-01	--	
M	00	-01	01	-00	-01	03	04	01	01	02	06	04	--
	A	B	C	D	E	F	G	H	I	J	K	L	M

A. Higher mathematics grades in high school
B. Higher overall high school G.P.A.
C. Higher physical science grades in high school
D. Air traffic control experience in military (IFR operations)
E. Worked in ATC-related job in military
F. Self-expected: less time will be required to become effective as an ATCS
G. Self-expected: performance level will be in top 10% of all ATCSs
H. Will not be difficult adjusting to rotating work schedule
I. Number of times OPM tests were taken prior to being hired
J. Benefits of "very great importance" in choice of occupation
K. Often talks to friend/co-worker/family member when tense
L. Often engages in yoga, meditation, etc. when tense
M. Grew up in a city of 500 thousand people or more

(N = 3,454; entrants who responded to all items)

* Spearman correlation coefficients $p \leq .001$

Post-High School Educational Background and Academy Success.

Consistent with previous research (2), Table 4 shows that, several BQ items that assessed the entrant's general educational background (e.g. attending college and/or receiving a college degree) were not significant predictors of Academy success. In the case of the BQ item - the number of college credit hours in aviation-related courses - there was a marginally significant relationship, with entrants who had completed 23 or more credit hours in aviation courses having an Academy pass rate of 63.4% compared to a pass rate of 58.5% for all other entrants who had attended college.

The two BQ items, a) the entrant's overall college grade point average (if a college graduate) and b) the number of credit hours in mathematics courses, had not been included in previous biographical questionnaires. As shown in Table 4, the 14.7% of the 1,529 entrants who were college graduates and reported earning outstanding grade point averages (above

3.50) had an Academy pass rate of 69.3%. Pass rates increased at each higher categorical level of grade point averages. Also, students who had successfully completed 13 or more semester hours in college mathematics had a significantly higher pass rate of 64.2%, compared to a pass rate of 57.2% for college students who had attended college but completed fewer than 13 credit hours in mathematics.

TABLE 4. College Educational Items from the BQ and Academy Success

BQ Item		% Passing Screen	% Item Frequency	N
Highest college degree you have received:	None	59.6	57.1	2041
	Associate	55.7	12.0	429
	Bachelor's	60.7	29.8	1067
	Graduate	50.0	1.1	40
	TOTALS:		100.0	3577
Attended college (any credit hours):	Did not attend	59.6	14.1	502
	Yes	59.3	85.9	3069
	TOTALS:		100.0	3571
Number of aviation-related college credits: *	22 hours or less	58.5	84.1	2577
	23 hours or more	63.4	15.9	487
	TOTALS:		100.0	3064
Overall G.P.A. - if received an Associate or Bachelor's Degree: **	2.00 or lower	50.0	0.9	14
	2.01 - 2.50	54.0	15.4	235
	2.51 - 3.00	55.4	38.1	583
	3.01 - 3.50	61.9	30.9	472
	3.51 - 4.00	69.3	14.7	225
	TOTALS:		100.0	1529
College semester hours in mathematics: **	12 hours or less	57.2	74.2	2222
	13 hours or more	64.2	25.8	774
	TOTALS:		100.0	2996

** Chi-square $p \leq .01$ * Chi-square $p \leq .05$

Relationships of BQ Items, Age, and Selection Test Scores with Academy Performance.

OPM selection tests scores, Occupational Knowledge Test scores, the entrants' ages, and certain biographical data have been demonstrated in previous research studies to be predictive of Academy success. However, the relative importance of each factor and the total effect of the combined set of factors on Academy performance have not been reported previously. To address this issue, the 13 BQ items in Table 3, along with TMC scores (Transmuted Composite - air traffic control aptitude measure), Occupational Knowledge Test scores, and the entrants' ages were included in a two-group (pass/not pass) discriminant analysis. A step-wise method was used for deriving the set of variables that best differentiated between the pass/not pass groups. The criterion for entry of a variable into the equation was a significance level of .01 and a resulting reduction by 1% or more in the Wilks' lambda (the ratio of within-groups sum of squares to total sum of squares).

TABLE 5. Discriminant Analysis of Academy Success; BQ Items and OPM Scores (Total Sample)

	N	%	
	1437	40.7	Failed or Withdrew
	2095	59.3	Passed FAA Academy
TOTAL	3532	100.0	

Wilks' lamba	Chi-square	Significance	Canonical correlation
0.883	438.54	0.000	.34

Pooled within-groups correlations between discriminating variables and Academy success
(Variables ordered by size of correlation within function)

.52	H.S. math grades
.42	Transmuted composite - ATC aptitude measure
-.40	Number of times the OPM tests were taken
.36	Self-expected level of performance compared to other ATCSs
-.34	Age at entry into the FAA Academy
.32	Occupational Knowledge Test score
.22	Military ATC experience (IFR operations)

As shown in Table 5, the discriminant analysis resulted in a derived set of four BQ variables, the TMC aptitude measure, the Occupational Knowledge Test score, and the entrant's age. The canonical correlation for this set of factors was .34 with Academy success for the 3,532 trainees with non-missing data on all the items. Pooled within-groups Pearson correlation coefficients between the variables and the discriminant function of Academy success were used to assess the relative importance of the items. The high school grade average in mathematics courses was the item with the highest correlation with pass/not pass. The age of the Academy entrant had a strong inverse relationship with Academy success: a finding consistent with previous research. Occupational Knowledge Test scores were more predictive of Academy performance than were self-reports of air traffic control experience in the military, as found previously (7).

Table 6 shows the trainee pass rates for the individual items selected in the previous analysis. For this table, the TMC, OKT, and age at Academy entry were recoded into categories. The "residual" represents, by integrating both the pass rate and the number of respondents in a given item category, the number of students in each item category who passed the Academy compared to the expected number of successful students based on a chi-square statistic. For example, of the students with an "A" average in high school mathematics courses, 139 more respondents passed the Academy screen than would have been expected by chance alone.

Academy pass rates of 70% or greater were indicated for trainees with an average of "A" in high school mathematics courses, or a score of 95.0 or greater on the TMC, or an OKT score of 52 or higher. The pass rates were less than 50% for entrants with an average of "C" in high school mathematics courses, or a TMC score less than 80, or an OKT score less than 20. The percentages of students who had taken the OPM tests three or more times prior to selection and subsequently passed the Academy screen were only 43.5% (OPM tests three times) and 38.2% (OPM tests four or more times), while those who took the test only once had a pass rate of 64.4%. Only 42.6% of trainees passed the Academy screen who expected that their performance level (compared to other ATCSs) would be "average or in the lower half," while 66.5% passed who had expected that their performance would be in the "top 10%."

TABLE 6. Pass Rates and Frequencies for Significant Items (Total Sample)

BQ Item	% Passing	Residuals*	% of Sample
H.S. Math grades -			
"A" average	70.9	139	34.5
"B" average	56.5	-48	46.7
"C" average or lower	45.8	-91	18.8
TMC aptitude test score -			
70 thru 79.99	47.7	-13	3.0
80 thru 84.99	53.7	-14	6.9
85 thru 89.99	52.1	-77	29.9
90 thru 94.99	59.9	8	42.4
95 +	74.4	96	17.8
Number of times the OPM tests were taken -			
One	64.4	109	61.3
Two	54.4	-52	29.2
Three	43.5	-45	8.0
Four or more	38.2	-12	1.5
Self-expected performance level (compared to other ATCS's) -			
Average or lower half	42.6	-34	5.7
In the upper half	55.8	-69	53.6
In the top 10%	66.5	103	40.7
Age at entry into Academy -			
22 years or younger	67.8	38	12.5
23 thru 27	61.8	52	56.7
28 years or older	51.1	-90	30.8
Occupational Knowledge Test score -			
0 - 19	47.6	-22	5.3
20 - 29	56.4	-38	35.2
30 - 39	57.2	-18	22.9
40 - 51	59.4	1	15.5
52+	77.7	77	21.1
Military IFP experience (18 months or more) -			
Yes	67.0	55	19.8
No	57.4	-55	80.2

* The number of entrants passing the FAA Academy minus the number expected (based on Chi-square statistic)

A more comprehensive depiction of the combined interaction of these predictors of Academy success is presented in Table 7. A discriminant function score was formulated for each member of the sample based on a) the function constant added to, b) the sum of the products of the discriminant coefficients for predictor variables and the values on those predictors for each entrant. These scores were then used to estimate the entrant's probability of passing the Academy screen.

The distribution of probabilities of passing the Academy screen was divided into five groups; less than 20% probability of success, 20% up to 40%, 40% up to 60%, 60% up to 80%,

and 80% or greater probability of success. The actual pass rates for the groups ranged from 23.2% to 90.1%. One-way analyses of variance were performed to provide the data for the group profiles. Specifically, the group with the highest pass rate (Group5; 90.1% passed the Academy) had the following combination of characteristics: 81.6% had excellent high school mathematics grades and no one indicated earning average grades; the group mean was 95.2 on the TMC aptitude test; 88.7% had taken the OPM tests only once prior to attending the Academy; 82.9% expected that their performance would be in the "top 10%" compared to other ATCSs; the average age was 23.9 years; the group mean was 51.9 on the Occupational Knowledge Test; and 41.8% indicated having prior air traffic control experience (IFR operations) in the military.

At the other end of the probability distribution, Group1 with a pass rate of 23.2% had the following profile: only 2.1% had excellent high school mathematics grades and 65.9% indicated earning average mathematics grades; the group mean was 85.2 on the TMC aptitude test; 15.9% had taken the OPM tests only one time prior to attending the Academy; 7.8% expected that their performance would be in the "top 10%" compared to other ATCSs; the average age was 28.1 years; the group mean was 29.9 on the Occupational Knowledge Test; and 18.1% indicated having prior air traffic control experience (IFR operations) in the military.

TABLE 7. Profiles of Academy Entrants Grouped by their Probability of Passing the Academy Based on Discriminant Function Scores.

	Group1	Group2	Group3	Group4	Group5
Probability of passing Academy - %	0-19.9	20-39.9	40-59.9	60-79.9	80+
Actual group pass rate - %	23.2	41.3	58.1	75.7	90.1
Proportion of sample - %	3.9	23.7	38.3	30.1	4.0
Entrants per group -n	138	838	1354	1061	141
H. S. math grade average "A"-%	2.1	6.9	29.6	60.9	81.6
H. S. math grade average "C"- %	65.9	38.9	14.1	5.1	0.0
TMC aptitude test scores - mean	85.2	88.8	90.7	92.7	95.2
Took the OPM tests one time - %	15.9	41.3	62.2	78.8	88.7
Expect to perform in top 10 - %	7.8	24.9	35.2	58.7	82.9
Age at entry into Academy - mean	28.1	26.9	25.8	24.9	23.9
Occupational Knowledge Test- mean	29.9	31.7	35.5	40.7	51.9
Military IFR experience - %	18.1	12.2	17.9	24.9	41.8

Validity of Biographical Data and TMC Scores in Predicting Academy Success.

The purposes of the following analyses were to separate the set of biographical data items and the entrant's age from the TMC aptitude measure to address two of the important issues identified by Hunter and Hunter (6) regarding alternative predictors (biographical data) of job performance: a) the relative importance of the alternative predictor compared to an aptitude measure (the TMC), and b) the potential increase in validity to be gained from combining predictors.

Table 8 presents the results of a discriminant analysis of Academy success using four significant items from the BQ and the entrants' ages, while excluding the selection test scores. As indicated, the canonical correlation was .29 or this set of variables with passing the Academy program. A discriminant function score was determined for each entrant from this discriminant analysis of biographical data and age items, and was then used as his/her "biodata" score in subsequent analyses.

TABLE 8. Discriminant Analysis of Academy Success: BQ Items and Entrant's Age

Wilks' lambda	Chi-square	Significance	Canonical correlation
0.915	312.34	0.000	.29

Pooled within-groups correlations and between discriminating variables and Academy success
(Variables ordered by size of correlation within function)

.62	H.S. math grades
-.48	Number of times the OPM tests were taken
.44	Self-expected level of performance compared to other ATCS's
-.40	Age at entry into the FAA Academy
.26	Military ATC experience (IFR operations)

Before the issues regarding biodata and aptitude measures could be explored, an important statistical issue had to be addressed arising from the fact that the sample in this study necessarily involved only a subset of ATCS applicants, i.e., those who had been hired. Specifically, successful applicants for the ATCS position are required to earn the minimum qualifying score of 70 on the TMC (but a score of 85 is preferred), while the possible range of TMC scores is 0 to 100 for all applicants. Thus, in any study of Academy entrants there will be a restriction in range on the TMC scores with a corresponding lower standard deviation when compared with the standard deviation for the population of all ATCS applicants. In this study, the standard deviation for the TMC was 4.81 for Academy entrants, compared with 13.67 for 29,896 applicants who took the OPM tests in 1986-1987. This rather severe restriction in range for the TMC scores clearly indicated that the correlation coefficients, computed between TMC scores and the Academy success criteria for our sample, were lower than would be expected had the population of all applicants who had taken the OPM tests actually attended the Academy program. To determine the validity of any measure used to select employees, a correction for the resultant restriction in range of selection test scores must be made (15).

Pearson correlation coefficients between TMC scores and the Academy performance criteria (also between the TMC scores and the biodata scores) were corrected for the restriction in range using the Thorndike Two Variable Case method (13). It was also assumed that the range of the responses on the biodata scores was restricted to the extent that the biodata item was correlated with the TMC. Thus, the correlation coefficients between the biodata values and the Academy performance measures were corrected with the Thorndike Three Variable Case method.

The intercorrelations and results of multiple regression analyses for both Academy performance criteria are shown in Table 9. The "uncorrected" Pearson correlations were .15 and .29 (for the TMC and the biodata scores, respectively) with "passing the Academy," while correlations were .20 and .32 (for the TMC and the biodata scores, respectively) with the final Academy score. The validity coefficients (corrected for the restriction in range) for the TMC were .41 with passing the Academy and .51 with the final Academy score, compared to corrected coefficients for the biodata of .36 with passing the Academy and .39 with the final Academy score.

The multiple regression analyses indicated that the addition of the biodata variable to the TMC increased the validity coefficient (i.e., multiple correlation) for passing the Academy screen from .41 for the TMC (only) to .48 for the combination of predictors. Similarly, the biodata measure increased the validity from .51 (TMC only) to .58 (both TMC and biodata predictors) with the final Academy score criterion.

TABLE 9. Multiple Regression Analyses of the TMC and Biodata Scores on FAA Academy Pass Rates and Final Academy Scores

(October 1985 - September 1987 Entrants)

Mean	SD	BETA Weight		TMC	Biodata
90.78	4.81	.33	TMC	--	
.00	1.05	.26	Biodata	.30 (.11)	--
1.59	.49		Criterion = Pass/not pass	.41 (.15)	.36 (.29)

N = 3532
Multiple Correlation = .48 with criterion for TMC combined with Biodata

Mean	SD	BETA Weight		TMC	Biodata
90.89	4.81	.44	TMC	--	
.05	1.03	.28	Biodata	.26 (.10)	--
72.86	10.55		Criterion = Academy score	.51 (.20)	.39 (.32)

N = 3156 (excludes entrants who withdrew before receiving final Academy score)
Multiple Correlation = .58 with criterion for TMC combined with Biodata
( ) These coefficients are uncorrected for restriction in range of TMC scores.

Crossvalidation

In order to test the applicability of these findings to an independent sample of Academy entrants, Biographical Questionnaire responses and OPM test scores were obtained for another sample of trainees who entered the FAA Academy between October 1987 and July 1989. Again, the "recycles" and those with missing OPM test scores were excluded from the sample. The discriminant function coefficients for the variables in the discriminant analysis described above for the 1985-1987 sample were applied to the 1987-1989 sample and discriminant function scores (biodata scores) were calculated for the trainees in the 1987-1989 group. The Pearson correlation coefficients (corrected for restriction in range as previously described) between biodata scores and the criteria indicated relatively small reductions in validity from the first to the second sample of Academy entrants (Table 10).

TABLE 10. Biodata Scores Correlated with Academy Performance Criteria

Biodata Scores	Pass Academy	N	Final Academy Scores	N
Oct 85 - Sept 87	.36	3532	.39	3156
Oct 87 - July 89	.33	3127	.37	2766

The intercorrelations between the TMC scores, biodata scores, and the criteria for the 1987-1989 sample used for crossvalidation are shown in Table 11. After adjusting the correlation coefficients for restriction in range of the TMC, the multiple correlation of the TMC combined with biodata was .47 with passing the Academy and .60 with the final Academy score.

TABLE 11. Multiple Regression Analyses of the TMC and Biodata Scores on FAA Academy Pass Rates and Final Academy Scores

Crossvalidation : October 1987 - July 1989 Entrants

Mean	SD	BETA Weight		TMC	Biodata
90.84	4.84	.34	TMC	--	
.11	.99	.26	Biodata	.19 (.07)	--
1.55	.50		Criterion = Pass/not pass	.39 (.15)	.33 (.29)

N = 3127
Multiple Correlation = .47 with criterion for TMC combined with Biodata

Mean	SD	BETA Weight		TMC	Biodata
90.92	4.84	.48	TMC	--	
.16	.98	.29	Biodata	.17 (.06)	--
72.16	11.23		Criterion = Academy score	.53 (.22)	.37 (.34)

N = 2766 (excludes entrants who withdrew before receiving final Academy score)
Multiple Correlation = .60 with criterion for TMC combined with Biodata

( ) These coefficients are uncorrected for restriction in range of TMC scores.

Biographical Questionnaire Items and Academy Performance for Female Trainees.

Table 12 shows the BQ items for women that were significantly correlated (Spearman coefficients $p \leq .01$) with at least one of the criterion measures. Only one of the BQ items, i.e. "the extent to which you believe that the FAA will provide good job security," was unique to this demographic group. The pass rate was 69% for those trainees who reported achieving excellent grades in high school mathematics courses. Less than one-third of the women with an overall high school grade point average of "C" passed the screen. Less than 40% were successful at the Academy who had taken the OPM tests three or more times prior to entry. Women who reported having grown up in a metropolitan environment had a pass rate of only 42.2%, and those who were 28 years or older at the time of Academy entry had a relatively low pass rate of 45.2%. Self-confidence, as measured by the expected time that would be needed to become fully effective as an ATCS, was also related to Academy performance.

The item response frequencies for females, compared with males, are also shown in Table 12. The female group reported achieving better high school grades, expected that it would take longer to become fully effective as ATCSs, and had repeated the OPM aptitude tests more often than the male trainees.

Table 13 shows the results of a discriminant analysis for the pass/not pass groups of women, using the significant BQ items (for females only) and the entrants' ages. The results for women indicated that high school mathematics grade average was the item most highly related to Academy success. Self-assessment of future performance and age factors were not as highly related to Academy performance for females as for males. The canonical correlation was .32 with passing the Academy for the 471 female trainees with nonmissing data for all items.

TABLE 12. Pass Rates of Female Trainees for Significant* BQ Items and Item Frequencies for Females/ Males

BQ item	% Passing	% Item Freq. (n=474)	% Item Freq. for Males
H.S. math grades -			
"A" average	69.0	44.3	33.0 **
"B" average	46.8	42.8	47.3
"C" average or lower	44.3	12.9	19.7
Overall high school average-			
"A" average	67.1	35.2	17.7 **
"B" average	53.2	56.8	59.6
"C" average or lower	32.3	8.0	22.7
Number of times the OPM tests were taken -			
One	63.9	52.6	62.7 **
Two	51.5	34.5	28.3
Three or more	39.4	12.9	9.0
Where have you lived most of the time -			
Less than 500,000	58.5	86.5	86.3
City > 500,000	42.2	13.5	13.7
Expect that FAA will provide good job security -			
Limited or not at all	65.2	4.9	5.2
Moderate extent	58.9	23.7	19.8
Considerable extent	60.9	46.5	47.0
Very great extent	44.9	24.9	28.0
Self-expected time to become fully effective in job (compared to other ATCSs)			
Much less time	63.0	5.7	11.6 **
Somewhat less time	61.9	38.2	48.3
About the same as others	52.4	52.3	35.6
Somewhat or much longer	46.2	3.8	4.5
Age at entry into Academy -			
22 years or younger	59.7	14.2	12.2
23 thru 27	60.4	59.2	56.4
28 years or older	45.2	26.6	31.4

* Spearman correlation coefficients $p \leq .01$

** BQ items with different response patterns between female/male groups Chi-square $p \leq .001$

TABLE 13. Discriminant Analysis of Academy Success; BQ Items and Age (Females Only)

	N	%	
	205	43.5	Failed or Withdrew
	266	56.5	Passed FAA Academy
TOTAL	471	100.0	

Wilks' lambda	Chi-square	Significance	Canonical correlation
0.896	50.92	0.000	.32

Pooled within-groups correlations between discriminating variables and Academy success (Variables ordered by size of correlation within function)

.64	H.S. math grades
.59	Higher overall high school G.P.A.
-.52	Number of times the OPM tests were taken
-.34	Grew up in city of 500 thousand or more
.30	Less likely to believe FAA will provide "very great" job security
.28	Expect less time will be required to become effective as ATCSs
.24	Age at entry into the FAA Academy

Biographical Questionnaire Items and Academy Performance for Minority Trainees.

Table 14 shows the BQ items that were significantly correlated (Spearman coefficients $p \leq .01$) with the criterion measures for minority entrants. The pass rates for the significant BQ items for minorities, and the item response frequencies for minorities compared with non-

TABLE 14. Pass Rates of Minority Group Trainees for Significant* BQ Items and Item Frequencies for Minorities/ Nonminorities

BQ item	% Passing	% Item Freq. (N=215)	% Item Freq. Nonminority
H.S. math grades -			
"A" average	65.7	31.2	35.0
"B" average	54.1	50.7	46.3
"C" average or lower	28.2	18.1	18.7
Number of times the OPM tests were taken -			
One	60.6	46.0	62.8 **
Two	51.2	38.1	28.3
Three or more	35.3	15.9	8.9
Where have you lived most of the time -			
Less than 500,000	59.7	67.3	87.6 **
City > 500,000	38.6	32.7	12.4
Age at entry into Academy -			
22 years or younger	66.7	11.2	12.6
23 thru 27	58.5	54.8	56.8
28 years or older	39.7	34.0	30.6

* Spearman correlation coefficients $p \leq .01$
** Items with different response patterns between minority/ nonminority groups - Chi-square $p \leq .001$

minorities are also shown in Table 14. Academy pass rates were above 60% for minority group members with excellent grades in high school mathematics courses, who had not repeated the OPM selection tests, or who were 22 years or younger at entry into the Academy. By contrast, pass rates were less than 40% for those with average high school mathematics grades, who had taken the OPM tests three or more times, who had grown up in an urban environment, or were 28 years or older at entry into the Academy. The minority group members were more likely to have grown up in an urban environment, and had repeated the OPM aptitude tests more often than nonminority trainees.

In contrast to nonminorities, minority trainees' self-assessment of future performance and military ATC experience were not significantly related to Academy performance. A discriminant analysis (Table 15) was conducted to assess the relative importance of the significant BQ items and entrant's age for determining the characteristics of minority group members who were successful in the Academy screening program. The canonical correlation was .38 with passing the Academy for the 214 minority group trainees. As was the case with the female group, the average grade in high school mathematics courses was the item most highly related to Academy success for minority group members.

TABLE 15. Discriminant Analysis of Academy Success; BQ Items and Entrant's Age (Minority Group Members Only)

	N	%	
	101	47.2	Failed or Withdrew
	113	52.8	Passed FAA Academy
TOTAL	214	100.0	

Wilks' lambda	Chi-square	Significance	Canonical correlation
0.853	33.51	0.000	.38

Pooled within-groups correlations between discriminating variables and Academy success
(Variables ordered by size of correlation within function)

.64	H.S. math grades
-.49	Age at entry into the FAA Academy
-.49	Grew up in city of 500 thousand or more
-.48	Number of times the OPM tests were taken

CONCLUSIONS.

Generally, the demographic characteristics (gender, minority group membership, age, education level, and prior ATC experience) of more recent Academy entrants were found to be more similar to entrants from the immediate post-strike period 1981-1983 than to trainees who entered the Academy 1976-1981. Only 21% of the sample in this study reported having prior air traffic control experience, compared to 50% of the prestrike trainees.

The multivariate approach taken in this study allowed for the consideration of the total effects of several interrelated predictors. The results indicated that FAA Academy performance was best predicted by a combination of measures including paper-and-pencil ability tests, some aspects of prior academic achievement, age, self-assessment of future job performance, prior air traffic control work experience, and knowledge of air traffic control principles prior to entering the Academy. The results of regression analyses indicated that, while the ATC aptitude-based tests clearly had higher predictive validity than biodata scores, the addition of biographical data to the aptitude test scores significantly improved the predictability of Academy success.

While the age of Academy entrants continued to bear a strong and consistent relationship with Academy success, using other biodemographic factors to target recruitment would likely improve the selection process for ATCSs, including women and minority group applicants, resulting in higher Academy pass rates. It appears that the women who should be especially encouraged to apply for the ATCS occupation would have outstanding high school mathematics grades and/or overall grade point averages, be younger than 28 years old, and have a relatively high level of self-confidence concerning their potential for succeeding in this career field. Likewise, minority group members who have outstanding high school mathematics grades and who are younger than 28 years old would be likely to succeed in the Academy screening program. The finding that both women and minorities who grew up in an urban environment had relatively low Academy pass rates, suggests that strategies for recruiting in metropolitan areas might well be reexamined. Since the number of times that an applicant had taken the OPM tests prior to selection was inversely related to Academy success, the finding that both women and minorities had repeated the selection tests more often than men and nonminorities, indicated one factor related to lower pass rates for women and minorities. Regarding recruiting efforts directed toward college graduates, an emphasis on a high (over 3.0) overall grade point average would appear likely to have a positive impact on Academy pass rates.

Future Research.

Future research could be directed toward determining the validity of biodata measures, combined with performance measures from the Academy screen, in predicting criteria such as field training attrition, job performance ratings by supervisors, employee job satisfaction, and promotion to supervisory positions. Additional research should also be conducted to evaluate the adverse impact (if any) of aptitude tests versus biodata measures on the selection rates of minority and female applicants.

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