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THE RELATIONSHIP OF PREDEVELOPMENTAL "150" TRAINING WITH NONCOMPETITIVELY SELECTED AIR TRAFFIC CONTROL TRAINEES TO FAA ACADEMY SUCCESS

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16. Abstract

Past studies have demonstrated that women and minorities are less likely to be selected as FAA air traffic controllers than are nonminority men, and, when selected, are less likely to be successful. One major reason for this is that women and minorities have less aviation-related background experience. In response to this need the "150" Predevelopmental program was begun to give those selected for the program a 1-year orientation to aviation and air traffic control prior to FAA Academy training. The purpose of this research was to study the unique relationship between Predevelopmental training and Academy success. An overview of the relationships between various background characteristics, selection measures, Predevelopmental training measures, and Academy measures was first computed. Then, through path analysis the significant relationships were considered simultaneously to determine the unique relationship between Predevelopmental training and Academy success. The path models indicated that Predevelopmental training overall does enhance a trainee's potential for Academy success with a possible differential effect according to minority status.

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THE RELATIONSHIP OF PREDEVELOPMENTAL "150" TRAINING WITH NONCOMPETITIVELY SELECTED AIR TRAFFIC CONTROL TRAINEES TO FAA ACADEMY SUCCESS

I. Introduction.

Several past studies have indicated that prior air traffic control (ATC) experience (usually from military service) is strongly related to being selected for ATC training in the Federal Aviation Administration (FAA) and to later success in FAA ATC training (2,3,10). It was also noted in these studies that women who are selected for training have significantly less prior ATC experience than do men (1). More recent unpublished reports (6) demonstrate that minorities are also less apt to have prior ATC experience than are nonminorities. Based on the above information related to experience and other existing social conditions, women and minorities have not been represented in ATC to the extent that nonminority men have. Civil Aeromedical Institute (CAMI) records during 1976 show that 79 percent of ATC trainees who entered the FAA Academy were nonminority men, while women and minorities combined comprised the remaining 21 percent.

In response to a need for more minority and women selectees in ATC, the Predevelopmental "150" program was begun in 1968. This 1-year program, conducted primarily at field facilities includes a 17-week set of 15 courses taught at the FAA Academy related to basic education, aviation principles, and principles of air traffic control. Onsite orientation is also provided. The program is designed to compensate for deficiencies in the backgrounds of trainees prior to their entry into formal air traffic control training at the FAA Academy. Various evaluations of the "150" program in the past have been aimed at determining if the selection of women and minorities through the "150" program resulted in a higher percentage of women and minorities in ATC work (8,9). However, there has not been an explicit study to determine if the training received in the "150" program, which constitutes a 1-year agency investment in every "150" trainee, has indeed produced a direct impact on the "150" trainee's ability to achieve success in air traffic control. Although no measures are taken to determine how much is learned through onsite orientation, tests are administered during the 17 weeks of Academy training and the scores are recorded. This study is directed toward determining the unique relationship between predevelopment training scores and the trainee's ability to achieve success in FAA Academy training.

II. Methods.

Subjects. The sample consisted of all persons who came through the Predevelopmental (FAA-150) program in calendar years 1974, 1975, and 1976, who finished Academy training between January 1976 and March 1977, and for whom CAMI had both Predevelopmental and Academy training scores. The final number of persons in the study was n = 157.

Variables included in the study. Variables are listed below with the abbreviated form to be used in this report.

Variable	Code	Abbreviation
1. Sex	(1 = woman, 2 = man)	SEX
2. Minority Status	(1 = nonwhite, 2 = white)	MINSTA
3. Option	(1 = Terminal, 2 = En Route)	OPTION
4. Education	(1 = No College, 2 = Some College, 3 = Degree)	ED
5. ATC Experience	(1 = Yes, 2 = No)	EXP
Civil Service Commission Scores		
6. Part Score 24 - Computations		CSC24
7. Part Score 51 - Spatial Patterns		CSC51
8. Part Score 540 - ATC Aptitude I & II		CSC540
9. Part Score 157 - Letter Sequence		CSC157
10. Part Score 135 - Oral Directions		CSC135
11. CSC Composite Score		COMP
12. CSC Earned Rating (includes experience and preference points)		CSCER
Academy Scores		
13. Academy Final Phase Score 2		PH1
14. Academy Final Phase Score 3		PH2
15. Academy Final Phase Score 4		PH3
16. Total Lab Z-Score		ZLAB
Predevelopmental Program Scores		
17. Communications		COMM
18. Social Studies		SOCSTU
19. Human Relations		HUMREL
20. Mathematics		MATH
21. Computations		COMPUT
22. Weather		WEA
23. Navigation		NAV
24. Federal Aviation Regulations		FAR
25. Flight Service Station		FSS
26. Aerodynamics		AERO
27. Aircraft Identification		ACRTID
28. National Airspace System		NAS
29. Air Traffic Control		ATC
30. Aviation History		AVNHIS
31. Facility Management		FACMAN
32. Average for Predevelopmental Scores		AVER

Analyses. The first stage of the analyses described the predevelopmental subjects in terms of their background characteristics, i.e., sex,

minority status, education, experience; scores on the Civil Service Commission tests; scores on tests given during the Predevelopmental program; and scores made on the lab problems during Academy training. The description of these characteristics and scores were in the form of means, standard deviations, and sample sizes for each variable.

The second stage of the analyses was exploratory. Initially, how all of the background characteristics and scores are related to each other was explored by means of a correlation index, computed by pairing all the characteristics and scores. Next, a series of analyses of variance were computed. These analyses were used to determine if the predevelopmentals differed on their scores according to their background characteristics. For example, do men score higher than women on the Civil Service Commission tests? The last step in exploration involved a statistical look at the pass/fail rates in Academy training by each of the background characteristics to determine, for example, if women fail more often than men. Chi-Square was used to test for differences. In all cases, statistical significance was set at $\alpha = .05$ (or better) level of chance.

In the last step of the analyses all the exploratory measures were reviewed, and the significant measures were used to develop models in the form of path diagrams to explain the unique relationship between the Predevelopmental program and Academy success.

III. Results.

Descriptive Statistics. There are a few items to note in relation to the descriptive statistics (Table 1). First, the mean scores for the Predevelopmental program tests are quite high, generally around 90 (out of a possible 100) with an overall average of 91.75. Second, the Academy scores for predevelopmentals are low for all training phases and for the overall ZLAB. (Note: The phase and ZLAB scores are in standard score form; therefore, a negative score means it is that many standard deviations below the mean.) Another item related to the Academy scores is the large standard deviations; there was a large range in the scores for Academy training. The lowest sample size (n) is for the Civil Service Commission scores (about 50 percent of the total sample). Finally, the frequencies in the data (Tables 2-6) are about equal for sex, minority status, and option. Notable deviations occur for nonminority men and for minority women, both of whom are represented somewhat less than their counterparts.

Exploratory Statistics (Table 7). Correlations between the following variables were selected for further study in the explanation section. They by no means define all possible meaningful correlations about which questions could be posed; however, they do appear to be the more useful ones. The paired variables and their correlations are: (1) SEX - COMP = 0.129, (2) MINSTA - COMP = 0.118, (3) MINSTA - ZLAB = 0.239, (4) MINSTA - AVER = 0.343, (5) OPTION - AVER = 0.225, (6) COMP - ZLAB = 0.161, (7) COMP - AVER = 0.204, and (8) ZLAB - AVER = 0.464. As can be seen, minority status correlates

TABLE 1. Descriptive Statistics for All Variables.

Variable	Mean	S.D.	N
SEX	1.48	0.50	157
MINSTA	1.46	0.50	157
OPTION	1.51	0.50	157
CSC24	46.11	7.75	83
CSC51	57.65	9.68	79
CSC540	37.81	11.46	80
CSC157	69.71	15.18	80
CSC135	27.13	5.31	78
COMP	79.45	7.27	88
CSCER	81.74	7.82	58
PH1	-0.85	1.98	153
PH2	-1.43	2.43	154
PH3	-1.08	1.36	154
ZLAB	-1.84	2.40	153
COMM	90.54	5.04	155
SOCSTU	90.58	5.07	36
HUMREL	86.48	7.72	23
MATH	91.79	9.26	155
COMPUT	92.31	6.93	154
WEA	92.33	6.24	155
NAV	92.06	6.61	155
FAR	93.50	5.54	155
FAS	92.58	6.33	155
AERO	95.04	5.59	155
ACRTID	89.21	9.15	155
NAS	94.24	5.11	153
ATC	90.21	4.97	155
AVNHIS	87.41	5.52	116
FACMAN	90.14	6.29	129
AVER	91.75	4.08	155
ED	1.93	0.56	98
EXP	1.73	0.44	98

Table 2. Two-Way Frequencies for SEX by OPTION.

	Ter	EnR	Total
Males :	41	41	82
Females :	36	39	75
Total :	77	80	157

Phi = .02
X^2 = .063, df = 1, p = ns

Table 3. Two-Way Frequencies for SEX by MINSTA.

	Min	Non	Total
Males :	59	23	82
Females :	26	49	75
Total :	85	72	157

Phi = .35
X^2 = 21.93, df = 1, p < .001

Table 4. Two-Way Frequencies for MINSTA by ED.

	No Inf.	No Coll	Some Coll	Deg.	Total
Min :	35	10	35	5	85
Non Min :	24	9	32	7	72
Total :	59	19	67	12	157

Phi = .07
X^2 = .048, df = 2, p = ns

Table 5. Two-Way Frequencies for MINSTA by EXP.

	No Inf.	Exp.	No Exp.	Total
Min :	35	15	35	85
Non Min :	24	11	37	72
Total :	59	26	72	157

Phi = .08
X^2 = .63, df = 1, p = ns

Table 6. Two-Way Frequencies for MINSTA by OPTION.

	Ter	EnR	Total
Min :	50	35	85
Non Min :	27	45	72
Total :	77	80	157

Phi = .21
X^2 = 7.09, df = 1, p < .01

TABLE 7. Intercorrelation Matrix for Background Characteristics and Measures.

SEX	MINSTA	OPTION	CSC24	CSC51	CSC540	CSC157	CSC135	COMP	CSCER	PH1	PH2	PH3	ZLAB	COMM	SOCSTU	HUMREL	MATH	COMPUT	WEA	NAV	PAR	PAS	AERO	ACRYLD	MAS	ATC	AVWHLS	PACMAN	AVER
SEX	0.374 137*	0.020 157	0.252 83	-0.228 79	0.135 80	0.132 80	0.116 78	0.129 88	-0.055 58	0.026 153	-0.045 154	0.013 154	-0.028 153	0.189 155	0.128 36	-0.027 23	0.123 155	0.103 156	-0.005 155	0.100 155	0.009 155	-0.014 155	-0.148 155	-0.202 155	-0.044 153	-0.022 155	-0.155 116	0.013 129	-0.011 155
	MINSTA	0.213 157	0.189 83	0.059 79	-0.148 80	0.144 80	0.092 78	0.118 88	0.220 58	0.328 153	0.251 154	0.355 154	0.239 153	0.327 155	0.239 36	0.309 23	0.407 155	0.269 154	0.270 155	0.337 155	0.251 155	0.180 155	0.073 155	0.194 155	0.119 155	0.312 155	0.146 116	-0.098 129	0.343 155
		OPTION	-0.179 83	0.161 79	-0.264 80	0.166 80	-0.213 78	-0.069 88	0.092 58	0.402 153	-0.096 154	-0.039 154	-0.072 153	0.210 155	0.389 36	0.326 23	0.141 155	0.189 154	0.230 155	0.213 155	0.150 155	0.100 155	0.164 155	0.169 155	0.145 153	0.135 155	-0.005 116	0.170 129	0.225 155
			CSC24	-0.169 79	0.267 80	-0.048 80	0.160 78	0.385 83	0.224 46	0.136 81	0.133 82	0.102 82	0.194 81	0.155 82	-0.060 22	-0.229 17	0.238 82	0.115 82	0.195 82	0.081 82	0.085 82	0.143 82	-0.088 82	0.110 82	0.124 81	0.204 82	0.148 57	-0.022 62	0.199 82
				CSC51	-0.361 79	0.087 78	0.011 77	0.258 79	0.272 45	0.101 77	0.082 78	-0.148 78	-0.016 77	-0.070 78	0.381 19	0.485 14	0.040 78	0.048 78	0.145 78	0.010 78	-0.018 78	0.001 78	0.116 78	0.230 78	0.065 77	0.168 78	-0.275 56	0.083 61	0.056 78
					CSC540	-0.047 79	0.163 77	0.430 80	0.352 46	0.012 78	-0.057 79	0.151 79	0.073 78	0.092 79	-0.313 19	-0.517 16	-0.116 79	-0.119 79	-0.061 79	0.079 79	0.056 79	-0.138 79	-0.060 79	-0.184 79	-0.127 78	-0.046 79	0.038 57	0.090 62	-0.053 79
						CSC157	0.067 78	0.641 80	0.599 45	0.219 78	0.089 79	0.041 79	0.101 78	0.015 79	0.195 20	0.045 15	0.230 79	0.174 79	0.260 79	0.139 79	0.056 79	0.086 79	-0.066 79	0.193 79	0.166 78	0.191 79	-0.074 56	0.049 61	0.129 79
							CSC135	0.422 76	0.137 45	0.002 76	0.132 77	0.169 77	0.184 76	0.303 77	0.612 20	0.235 15	0.184 77	0.186 77	0.037 77	0.025 77	-0.051 77	-0.010 77	-0.003 77	0.038 77	0.060 76	0.224 77	0.088 54	-0.053 59	0.090 77
								COMP	0.840 50	0.188 86	0.123 87	0.095 87	0.161 86	0.192 87	0.517 22	0.055 17	0.225 87	0.184 87	0.309 87	0.116 87	0.150 87	0.074 87	-0.023 87	0.176 87	0.125 86	0.308 87	-0.010 62	0.038 67	0.204 87
									CSCER	0.274 56	0.172 57	0.012 57	0.141 56	0.174 57	0.117 16	0.101 11	0.106 57	0.063 57	0.385 57	0.219 57	0.213 57	0.038 57	-0.070 57	0.248 57	0.039 56	0.350 57	0.000 41	0.287 46	0.215 57
										PH1	0.199 153	0.387 153	0.372 152	0.381 151	0.341 34	0.362 23	0.591 151	0.571 150	0.504 151	0.469 151	0.396 151	0.409 151	0.264 151	0.321 151	0.275 148	0.449 151	0.183 114	0.212 125	0.574 151
											PH2	0.413 154	0.852 153	0.100 152	0.148 34	-0.021 23	0.251 152	0.181 151	0.222 152	0.195 152	0.303 152	0.033 152	0.262 152	0.336 152	0.221 150	0.301 152	0.109 115	0.038 126	0.314 152
												PH3	0.380 153	0.311 152	0.132 34	0.044 23	0.487 152	0.423 151	0.381 152	0.453 152	0.408 152	0.195 152	0.249 152	0.331 152	0.265 150	0.461 152	0.312 115	0.121 126	0.526 152
													ZLAB	0.222 151	0.261 34	0.129 23	0.417 151	0.328 150	0.337 151	0.348 151	0.394 151	0.130 151	0.318 151	0.342 151	0.313 148	0.448 151	0.128 114	0.043 125	0.464 151
														COMM	0.532 36	0.395 23	0.407 155	0.452 154	0.487 153	0.502 155	0.384 155	0.555 155	0.266 155	0.250 155	0.273 155	0.392 155	0.317 116	0.255 129	0.618 155
															SOCSTU	0.204 23	0.329 36	0.220 36	0.338 36	0.139 36	0.408 36	0.552 36	0.289 34	0.378 36	0.508 36	0.348 36	----- 0	0.379 13	0.599 36
																HUMREL	0.303 23	0.384 23	0.487 23	0.639 23	0.487 23	0.524 23	0.547 23	0.061 23	0.138 23	0.337 23	----- 0	----- 0	0.408 23
																	MATH	0.454 154	0.472 155	0.574 155	0.513 155	0.313 155	0.226 155	0.346 155	0.384 153	0.500 155	0.271 116	0.175 129	0.709 155
																		COMPUT	0.390 154	0.582 154	0.482 154	0.428 154	0.250 154	0.283 154	0.342 152	0.399 154	0.356 115	0.216 128	0.678 154
																			WEA	0.692 155	0.593 155	0.362 155	0.343 155	0.421 155	0.292 153	0.644 155	0.408 116	0.211 129	0.723 155
																				NAV	0.542 155	0.402 155	0.319 155	0.401 155	0.359 153	0.587 155	0.383 116	0.119 129	0.771 155
																					PAR	0.340 153	0.357 155	0.438 155	0.421 153	0.639 155	0.382 116	0.104 129	0.719 155
																						PAS	0.200 155	0.273 155	0.379 153	0.481 155	0.331 116	0.263 129	0.386 155
																							AERO	0.261 155	0.288 153	0.323 155	0.274 116	0.201 129	0.471 155
																								ACRYLD	0.434 153	0.511 155	0.216 116	0.103 129	0.630 155
																									MAS	0.331 153	0.237 114	0.209 127	0.391 153
																										ATC	0.397 116	0.224 129	0.750 155
																											AVWHLS	0.260 116	0.545 116
																												PACMAN	0.370 129
																													AVER

*Sample size for correlation coefficient is listed under each coefficient.

well with AVER, and AVER correlates well with ZLAB. These relationships will be of particular interest in explanation.

The next set of exploratory statistics is transitional since the analyses edge into the area of explanation. These consist first of several one-way analyses of variances. These analyses determine if there are statistically significant differences in (i) Civil Service Commission composite scores (COMP), (ii) Predevelopmental program total average scores (AVER), and (iii) Academy training lab (ZLAB) totals (three dependent measures), based on whether the subjects are (i) men or women (SEX), (ii) En Route or Terminal (OPTION), (iii) minority or nonminority (MINSTA), and on (iv) educational level (ED), and (v) ATC experience (EXP) (five independent variables). The following differences were found to be statistically significant: (1) MINSTA for ZLAB, (2) MINSTA for AVER, and (3) OPTION for AVER. Again note the effect of minority status. Results of analyses of variance form part of the background for analytic discussion in the next section.

The second set of analyses in the transitional exploratory area comprises two-way frequency tables (Tables 23-31). These tables present the Academy pass/fail rates by sex, minority status, option, and the various combinations. A Phi coefficient and a Chi-Square statistic were computed for each table to determine if there was a statistically significant difference in the pass/fail rates for that variable. Pass/fail rates found significantly different were: (1) MINSTA for pass/fail, (2) MINSTA (men only) for pass/fail, and (3) MINSTA (En Route only) for pass/fail. This third set of exploratory statistics again emphasizes minority status.

Explanatory Statistics. The exploratory statistics presented above are relatively strightforward computations that offer insight in terms of relationships or differences; however, they are inadequate (although they are often so used incorrectly) to directly explain or to infer causality for controlling effects. What is needed is a way to consider the relationships between variables simultaneously and to consider the unique contribution of each of the independent variables to the dependent variable of interest. This can be done by constructing path diagram models and using correlations to perform a series of multiple linear regressions to determine the path coefficients (Betas). Given proper assumptions, the coefficients can then be interpreted as the unique contribution of each path in explaining variance in the dependent variable (5). The correlations presented above revealed some interesting relationships that can be used to develop path diagrams.

The first diagram relates to the following questions: If the CSC COMP scores represent a measure of the ability of predevelopmentals to achieve Academy success prior to predevelopmental training, how much does predevelopmental training add to their ability to achieve Academy success? After partialling out the trainee's ability level prior to predevelopmental training, how much does predevelopmental training contribute to Academy success? The questions can be expressed in the model presented in Figure 1.

TABLE 8. Analysis of Variance: Sex Effect for CSC Composite.

	N	Mean	S.D.
Males :	28	82.18	8.40
Females :	30	81.33	7.35

Source	SS	df	MS	F
Between Groups :	10.31	1	10.31	0.17 ns
Within Groups :	3472.78	56	62.01	
Total :	3483.09	57		

Level of significance is indicated by ns (nonsignificant), * (p = .05), ** (p = .005), and *** (p = .001).

TABLE 9. Analysis of Variance: Education Effect for CSC Composite.

	N	Mean	S.D.
No Coll :	6	82.50	6.98
Some Coll :	26	82.04	6.09
Degree :	3	85.33	12.34

Source	SS	df	MS	F
Between Groups :	29.27	2	14.63	0.32 ns
Within Groups :	1475.14	32	46.10	
Total :	1504.41	34		

Level of significance is indicated by ns (nonsignificant), * (p = .05), ** (p = .005), and *** (p = .001).

TABLE 10. Analysis of Variance: Experience Effect for CSC Composite.

	N	Mean	S.D.
Exp. :	11	84.00	5.22
No Exp. :	24	81.67	7.20

Source	SS	df	MS	F
Between Groups :	41.08	1	41.08	0.93 ns
Total :	1504.41	34		

Level of significance is indicated by ns (nonsignificant), * (p = .05), ** (p = .005), and *** (p = .001).

TABLE 11. Analysis of Variance: Minority Effect for CSC Composite.

	N	Mean	S.D.
Min. :	29	80.03	7.18
Nonmin. :	29	83.45	8.17

Source	SS	df	MS	F
Between Groups :	168.97	1	168.97	2.86 ns
Total :	3483.09	57		

Level of significance is indicated by ns (nonsignificant), * (p = .05), ** (p = .005), and *** (p = .001).

TABLE 12. Analysis of Variance: Option Effect for CSC Composite.

	N	Mean	S.D.
Terminal :	28	81.00	8.46
EnRoute :	30	82.43	7.24

Source	SS	df	MS	F
Between Groups :	29.75	1	29.75	0.48 ns
Total :	3483.09	57		

Level of significance is indicated by ns (nonsignificant), * (p = .05), ** (p = .005), and *** (p = .001).

TABLE 13. Analysis of Variance: Sex Effect for ZLAB.

	N	Mean	S.D.
Males :	81	-1.78	2.53
Females :	72	-1.91	2.25

Source	SS	df	MS	F
Between Groups :	0.70	1	0.70	0.12 ns
Total :	872.19	152		

Level of significance is indicated by ns (nonsignificant), * (p = .05), ** (p = .005), and *** (p = .001).

TABLE 14. Analysis of Variance: Experience Effect for ZLAB.

	N	Mean	S.D.
Exp. :	26	-2.29	2.43
No Exp. :	69	-2.09	2.79

Source	SS	df	MS	F
Between Groups :	0.71	1	0.71	0.10 ns
Total :	677.13	94		

Level of significance is indicated by ns (nonsignificant), * (p = .05), ** (p = .005), and *** (p = .001).

TABLE 15. Analysis of Variance: Minority Effect for ZLAB.

	N	Mean	S.D.
Min. :	83	-2.37	2.57
Nonmin. :	70	-1.22	2.01

Source	SS	df	MS	F
Between Groups :	49.98	1	49.98	9.18 **
Total :	872.19	152		

Level of significance is indicated by ns (nonsignificant), * (p = .05), ** (p = .005), and *** (p = .001).

TABLE 16. Analysis of Variance: Option Effect for ZLAB.

	N	Mean	S.D.
Terminal :	77	-1.67	1.91
EnRoute :	76	-2.01	2.81

Source	SS	df	MS	F
Between Groups :	4.49	1	4.49	0.78 ns
Total :	872.19	152		

Level of significance is indicated by ns (nonsignificant), * (p = .05), ** (p = .005), and *** (p = .001).

TABLE 17. Analysis of Variance: Education Effect for ZLAB.

	N	Mean	S.D.
No Coll :	17	-2.26	2.84
Some Coll :	66	-2.32	2.77
Degree :	12	-1.02	1.76

Source	SS	df	MS	F
Between Groups :	17.36	2	8.68	1.21 ns
Total :	677.13	94		

Level of significance is indicated by ns (nonsignificant), * (p = .05), ** (p = .005), and *** (p = .001).

TABLE 18. Analysis of Variance: Sex Effect for Predevelopmental Total Average.

	N	Mean	S.D.
Males :	81	91.79	3.77
Females :	74	91.70	4.43

Source	SS	df	MS	F
Between Groups :	0.25	1	0.25	0.01 ns
Total :	2569.13	154		

Level of significance is indicated by ns (nonsignificant), * (p = .05), ** (p = .005), and *** (p = .001).

TABLE 19. Analysis of Variance: Education Effect for Predevelopmental Total Average.

	N	Mean	S.D.
No Coll :	19	90.79	4.92
Some Coll :	66	91.65	4.06
Degree :	12	93.83	2.76

Source	SS	df	MS	F
Between Groups :	70.25	2	35.13	2.08 ns
Total :	1658.06	96		

Level of significance is indicated by ns (nonsignificant), * (p = .05), ** (p = .005), and *** (p = .001).

TABLE 20. Analysis of Variance: Experience Effect for Predevelopmental Total Average.

	N	Mean	S.D.
Exp. :	25	92.76	3.96
No Exp. :	72	91.40	4.19

Source	SS	df	MS	F
Between Groups :	34.19	1	34.19	2.00 ns
Total :	1658.06	96		

Level of significance is indicated by ns (nonsignificant), * (p = .05), ** (p = .005), and *** (p = .001).

TABLE 21. Analysis of Variance: Minority Effect for Predevelopmental Total Average.

	N	Mean	S.D.
Min. :	84	90.46	4.20
Nonmin. :	71	93.27	3.39

Source	SS	df	MS	F
Between Groups :	302.38	1	302.38	20.41 ***
Total :	2569.13	154		

Level of significance is indicated by ns (nonsignificant), * (p = .05), ** (p = .005), and *** (p = .001).

TABLE 22. Analysis of Variance: Option Effect for Predevelopmental Total Average.

	N	Mean	S.D.
Terminal :	76	90.82	4.48
EnRoute :	79	92.65	3.46

Source	SS	df	MS	F
Between Groups :	129.63	1	129.63	8.13 **
Total :	2569.13	154		

Level of significance is indicated by ns (nonsignificant), * (p = .05), ** (p = .005), and *** (p = .001).

TABLE 23. Two-Way Frequency Distribution for Predevelopmentals (Total Group) by Sex.

	Pass		Fail		Total	
Males :	54	40%*	19	13%	73	53%
Females :	49	35%	15	12%	64	47%
Total :	103	75%	34	25%	137**	100%

Phi = .0299
Chi-Square = .123 df = 1 p = ns

*Proportions or probabilities based on total sample.
**One withdrawal (male, nonminority, EnRoute).

TABLE 24. Two-Way Frequency Distribution for Predevelopmentals (Total Group) by Minority Status.

	Pass		Fail		Total	
Min. :	51	37%*	27	20%	78	57%
Nonmin. :	52	38%	7	5%	59	43%
Total :	103	75%	34	25%	137**	100%

Phi = .2524
Chi-Square = 9.319 df = 1 $p \leq .01$

*Proportions or probabilities based on total sample.
**One withdrawal (male, nonminority, EnRoute).

TABLE 25. Two-Way Frequency Distribution for Predevelopmentals (Total Group) by Option.

	Pass		Fail		Total	
Terminal :	52	38%*	20	15%	72	53%
EnRoute :	51	37%	14	10%	65	47%
Total :	103	75%	34	25%	137**	100%

Phi = .0719
Chi-Square = .7127 df = 1 p = ns

*Proportions or probabilities based on total sample.
**One withdrawal (male, nonminority, EnRoute).

TABLE 26. Two-Way Frequency Distribution for Predevelopmentals (Female) by Minority Status.

	Pass		Fail		Total	
Min. :	15	23%*	8	13%	23	36%
Nonmin. :	34	52%	7	12%	41	64%
Total :	49	75%	15	25%	64**	100%

Phi = .1957
Chi-Square = 2.5752 df = 1 p = ns

*Proportions or probabilities based on total sample.
**One withdrawal (male, nonminority, EnRoute).

TABLE 27. Two-Way Frequency Distribution for Predevelopmentals (Female) by Option.

	Pass		Fail		Total	
Terminal :	25	39%*	9	14%	34	53%
EnRoute :	24	38%	6	9%	30	47%
Total :	49	77%	15	23%	64**	100%

Phi = .076
Chi-Square = .3719 df = 1 p = ns

*Proportions or probabilities based on total sample.
**One withdrawal (male, nonminority, EnRoute).

TABLE 28. Two-Way Frequency Distribution for Predevelopmentals (Male) by Minority Status.

	Pass		Fail		Total	
Min. :	36	49%*	19	26%	55	75%
Nonmin. :	18	25%	0	0%	18	25%
Total :	54	74%	19	26%	73**	100%

Phi = .3213
Chi-Square = 8.4061 df = 1 p ≤ .01

*Proportions or probabilities based on total sample.
**One withdrawal (male, nonminority, EnRoute).

TABLE 29. Two-Way Frequency Distribution for Predevelopmentals (Male) by Option.

	Pass		Fail		Total	
Terminal :	27	37%*	11	15%	38	52%
EnRoute :	27	37%	8	11%	35	48%
Total :	54	74%	19	26%	73**	100%

Phi = .0692
Chi-Square = .3510 df = 1 p = ns

*Proportions or probabilities based on total sample.
**One withdrawal (male, nonminority, EnRoute).

TABLE 30. Two-Way Frequency Distribution for Predevelopmentals (EnRoute) by Minority Status.

	Pass		Fail		Total	
Min. :	19	29%*	12	18%	31	47%
Nonmin. :	32	49%	2	4%	34	53%
Total :	51	78%	14	22%	65**	100%

Phi = .3705
Chi-Square = 10.3401 df = 1 p ≤ .01

*Proportions or probabilities based on total sample.
**One withdrawal (male, nonminority, EnRoute).

TABLE 31. Two-Way Frequency Distribution for Predevelopmentals (Terminal) by Minority Status.

	Pass		Fail		Total	
Min. :	32	44%*	15	21%	47	65%
Nonmin. :	20	28%	5	7%	25	35%
Total :	52	72%	20	28%	72**	100%

Phi = .1256
Chi-Square = 1.1548 df = 1 p = ns

*Proportions or probabilities based on total sample.
**One withdrawal (male, nonminority, EnRoute).

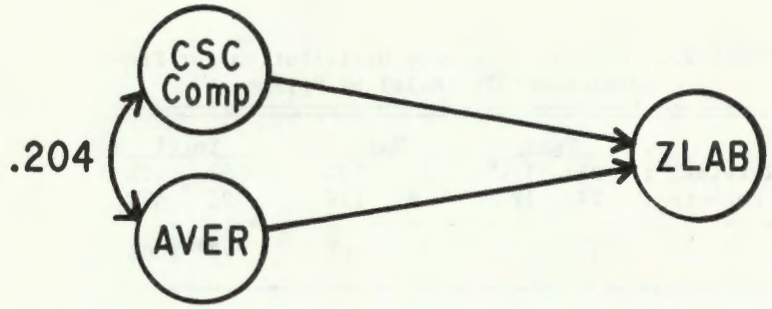

Figure 1. Path diagram for Model I (without path coefficients). Effect of Predevelopmental training on Academy success.

Regressing ZLAB on CSC COMP and predevelopmental AVER produces the relationships depicted in Figure 2.

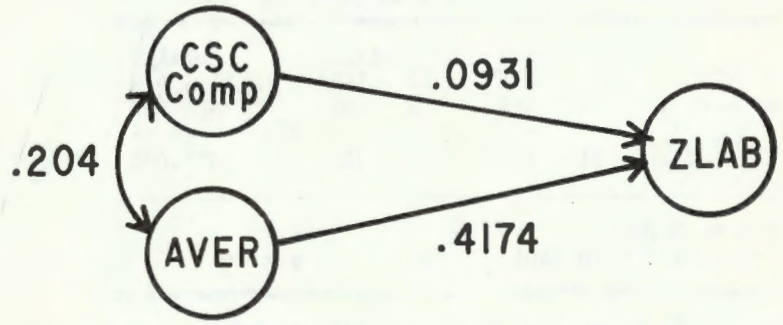

Figure 2. Path diagram for Model I (with path coefficients). Effect of Predevelopmental training on Academy success.

Clearly, the predevelopmental AVER adds a large amount of explanatory power relative to what CSC COMP does in explaining ZLAB scores. To determine how well the model represents the data, the original correlation matrix was reproduced by using the path coefficients. The coefficients above the diagonal are the original correlations; the coefficients below the diagonal are the reproduced correlations. As viewed from Table 32, the model represents the data very closely. This evidence supports the belief that the Predevelopmental program adds significantly to the trainee's ability to achieve success in the Academy program.

Building on the existing model, is there another variable chronologically preceding CSC COMP that might provide useful information? An obvious one that consistently showed up in the exploratory analyses was minority status, and another variable preceding CSC COMP chronologically is sex. So, another question can be posed: Does the relationship between the Predevelopmental

TABLE 32. Efficiency Table for Model I.

	CSC	Aver	ZLab
CSC	1.000	.204	.161
Aver	.204	1.000	.464
ZLab	.156	.436	1.000

Correlations above the diagonal are original; those below the diagonal are reproduced from path coefficients.

program and the ability to achieve Academy success differ according to minority status or sex? First, minority status is introduced into the model. To test this model, ZLAB scores were regressed directly on MINSTA, CSC COMP, and AVER to determine direct relationships, and then AVER was regressed on MINSTA and CSC COMP to determine indirect relationships. The results are presented in Figure 3.

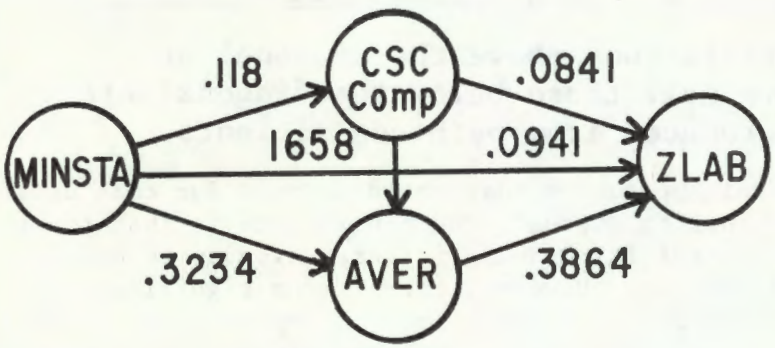

Figure 3. Path diagram for Model II. The influence of minority status on the effect of predevelopmental training on Academy success.

The model in Figure 3 demonstrates a mild direct contribution (.0841) of CSC COMP (the measure used to represent the ability to achieve Academy success prior to the predevelopmental training) and minority status (.0941) on ZLAB scores (Academy success). However, there is a strong direct contribution (.3864) of AVER (the Predevelopmental program effect) on ZLAB. Now, we can proceed to observe indirect paths.

There are two dominant indirect routes to ZLAB:
(1) MINSTA → CSC COMP → AVER → ZLAB, and
(2) MINSTA → AVER → ZLAB.

Clearly, the second route (See Figure 3) is superior to the first. Essentially, this model demonstrates that minority status makes little direct contribution to ZLAB (Academy success) for predevelopmentals, but when channeled through AVER (the Predevelopmental program), minority status makes a strong indirect contribution to Academy success. The evidence supports the idea that the Predevelopmental program produces a differential contribution in terms of the trainee's ability to achieve Academy success according to the trainee's minority status.

Again, the efficiency of the model can be observed by the reproduced correlation matrix in Table 33, and the fit is very close.

TABLE 33. Efficiency Table for Model II.

	Min	CSC	Aver	ZLab
Min	1.000	.118	.343	.239
CSC	.118	1.000	.204	.161
Aver	.341	.204	1.000	.464
ZLab	.237	.160	.436	1.000

Correlations above the diagonal are original; those below the diagonal are reproduced from path coefficients.

Are there rival hypotheses that could account for this differential contribution by minority status? One possibility is that the predevelopmentals differed in ability by minority status prior to entering the Predevelopmental program. However, there is no significant difference (Table 11) in CSC COMP (the measure used to represent prior ability) by minority status. Another possibility: the difference is due to differences in educational level or experience level, rather than minority status. Again, there are no significant differences by educational level or experience level on either AVER or ZLAB (Tables 14,17,19,20), and Tables 4 and 5 show education and experience do not differ by minority status. Still another possibility involves sex differences. But Table 8 shows no significant sex differences. For illustrative purposes sex was introduced into the model in place of minority status to demonstrate the difference from the minority model (Figure 4). As viewed from the model, sex makes little to no direct contribution (-.033) or indirect contribution (.0156) through AVER on ZLAB scores. It makes a mild indirect contribution through CSC COMP scores (.129). Comparison of the "above" and "below" diagonals on the reproduced correlation matrix in Table 34 demonstrates a close fit.

The exploratory statistics selected for analyses do not suggest any further model testing. The following three statements summarize the results of the model testing.

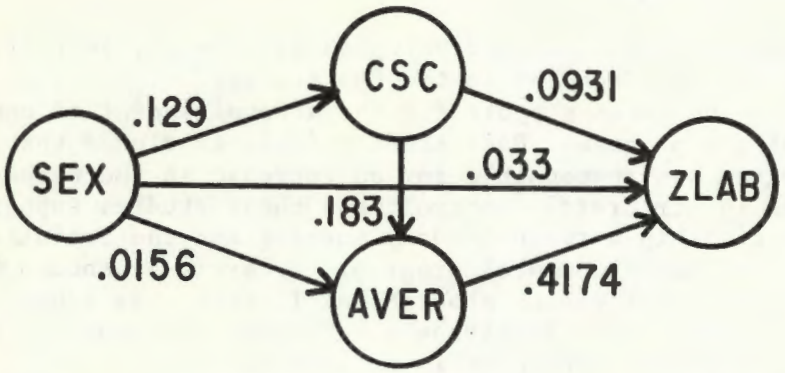

Figure 4. Path diagram for Model III. The influence of sex on the effect of Predevelopmental training on Academy success.

TABLE 34. Efficiency Table for Model III.

	Sex	CSC	Aver	ZLab
Sex	1.000	.129	-.011	-.028
CSC	.129	1.000	.204	.161
Aver	-.008	.191	1.000	.464
ZLab	-.026	.154	.436	1.000

Correlations above the diagonal are original; those below the diagonal are reproduced from path coefficients.

(1) Model I indicates that the Predevelopmental program (as measured by AVER) makes a significant addition to the trainee's ability to achieve success in the Academy (as measured by ZLAB) beyond his ability to achieve success in the Academy program prior to predevelopmental training (as measured by CSC COMP).

(2) Model II suggests that the contributions of the Predevelopmental program to the trainee's ability to achieve success in the Academy is differential according to minority status.

(3) Model III does not demonstrate a differential contribution by sex of the Predevelopmental program on the trainee's ability to achieve Academy success.

IV. Discussion of Results.

Model I indicates that the Predevelopmental program, overall, aids the disadvantaged to achieve success in the FAA Academy. This is an important finding, since it indicates support for the accomplishment of one of the primary goals of the program. Past studies (8,9) concluded that the Predevelopmental program was responsible for an increase in the number of disadvantaged persons in air traffic control, and these studies support the notion of a unique relationship between Academy success and the training they received in their Predevelopmental program. However, it should be pointed out concurrent with these statements about Model I, that this study is not designed to determine cost-effectiveness. Whether the benefit received from the program is worth the investment is another matter.

The implications of Model II are more difficult to assess. The tentative evidence of Model II supports the idea that nonminorities were aided by the program, but the extent of aid to minorities appears open to question. Several rival hypotheses were considered and rejected as explanations for this differential by minority status, *viz* initial ability (CSC scores), prior ATC experience, and educational level. The three major ability measurements, CSC COMP, AVER, and ZLAB, viewed independently by minority status suggests the possibility of another rival hypothesis. Tables 21, 15, and 11 show a significant difference by minority status for AVER and ZLAB; however, no significant difference is found in CSC scores by minority status.

This circumstance could obviously be due to several factors related to CSC scores. Since we had no quantitative data on CSC selection and testing procedures, direct contacts were made with the personnel in charge of CSC testing at FAA regional offices. Interviews with those persons yielded information that the Predevelopmental testing procedures included retesting those who scored below the cutoff point; a second or possibly a third testing might be allowed, sometimes with specially related remedial instruction given between the testing sessions. What effect might this situation have on the models?

Consider that observed test scores (O_i) consist of the true ability score (T_i) on that test and any error (E_i) involved in the measurement process.

$$O_i = T_i + E_i \qquad (1)$$

Repetitive testing of a group taking the higher scores on the average results in higher observed scores by adding to the error component. Consequently, scores inflated by the addition of error yield misleading estimates of potential success, since the observed scores are inaccurate estimates of the group's ability. Since retesting occurs predominantly for the group who score below the cutoff, the inflation of scores would occur predominantly at the lower end of the score continuum.

The effect of such a retesting procedure on Model I would not alter the conclusion based on that model, since a higher ability level based on CSC

scores would be partialled out of ZLAB scores prior to determining the contribution of the Predevelopmental program to what is left over in ZLAB after the partialling-out process. In this case (retesting), Model I would be a conservative estimate of the overall effect of Predevelopmental training on Academy success.

In terms of Model II, the results of a retesting procedure are quite different. It could well be that those retaking the CSC battery are in the minority status category. Retest scores would inflate the estimate of their ability and give the appearance of equal initial ability levels for minorities and nonminorities, when in fact their initial ability levels are quite different. This could account for the differential contributions by minority status in Model II. Likewise, it could account for the significant differences in Predevelopmental and ZLAB scores by minority status.

At present, data are not available on the selection process (in particular, CSC testing) so that determinations could be made of the effects of the selection procedures. However, it would appear economically and socially advantageous to perform such a study. First, suppose the predevelopmental failures at the Academy are primarily those who retook the CSC battery in order to score above the cutoff point. Use of the retesting procedure would not have gained the agency more minorities in ATC, rather the agency would have expended considerable resources only to fail them at the Academy, when those failing trainees could have been selected out initially. Second, such a study would help determine if a real differential does exist by minority status in the contribution predevelopmental training makes to Academy success. If in fact there is such a differential, the Predevelopmental training program should be assessed and redirected toward achieving the goal of enhancing the chances of minorities and women to be successful air traffic controllers.

There are at least four elements of this report that should be noted prior to generalizing the findings:

(i) Although the reported sample of trainees represents 3 years of students in the Predevelopmental program who have gone through Academy training between January 1976 and March 1977, the sample size is not ideal. Thus, the inferences drawn should be interpreted with some caution.

(ii) The second consideration is related to the first. In order to investigate the stability of the models, a cross-validation study should be performed as soon as more trainee data are available.

(iii) Causal models never prove causality (neither does any other statistical technique). Evidence is gathered which either supports or denies a proposition. The more evidence, the more sure the conclusions. Causal models such as path analysis offer evidence to infer causality.

(iv) Reliability and validity of measurement instruments:

a. Reliability.

1. CSC scores. A search through the available literature yielded no reliability information regarding these scores. A report by Mies (7) stated that such information was in an earlier report (4) by Education and Public Affairs, Inc. However, a close examination of the latter revealed no reliability data. It is perhaps safe to assume that the CSC has sufficient reliability information for the test to be in use.

2. ZLAB scores. Reliabilities were computed on ZLAB scores at CAMI for each input in 1976. The average of these coefficients (converting r's to Fisher's Z) was .73.

3. Predevelopmental scores. Reliability information was not available on predevelopmental scores; however, the average intercorrelation of the subscores (again, converting r's to Fisher's Z) was .44. This could be taken as an indication of the consistency of the measures.

b. Validity.

1. CSC scores. The 1970 Education and Public Affairs report (4) contains a thorough listing of validity studies on the CSC scores. The details of those studies will not be presented here, but the results were conflicting and inconclusive.

2. and 3. ZLAB and Predevelopmental scores. At present a field criterion has not been sufficiently developed for such a study. The intercorrelation between ZLAB and AVER is .464. This could be used as a coefficient of validity for predevelopmental scores.

V. Summary.

1. The results of this study indicate that Predevelopmental training, overall, enhances the predevelopmental's chances for success in ATC training at the FAA Academy. With this statement one is cautioned not to assume the program is particularly cost-effective or that the program could not be improved.

2. The study suggests further that the contributions of Predevelopmental training to Academy success could be differential according to minority status; however, this differential may be rooted in the procedures used for selection into the Predevelopmental program (particularly CSC retesting).

3. This study also demonstrates the need for a study into the selection procedures for the Predevelopmental program. Such a study could have both economic and social advantages.

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