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16. Abstract

This study compares age, education, pre-FAA experience, aptitudes, training-course performance measures, and post-Academy attrition rates of the 83 women who entered basic air traffic control (ATC) training at the FAA Academy during November 1968 through March 1970 with those of various samples of the 3,760 males who entered training during the same period. The study revealed no significant differences between the means of the female and male trainees with respect to age and educational level. When samples of the 83 females were compared with groups of male trainees in terms of performance on 36 different aptitude tests, only four mean differences, all of which favored the females, proved statistically significant. Only 45.8 per cent of the 83 women had pre-FAA ATC-related experience, while such experience was possessed by 63.9 per cent of a sample of 798 males; the difference was significant at the .01 level. The means of the training course grade averages of the two groups differed by only three-tenths of one point and there was no significant difference between the Academy attrition rate of 20.5 per cent for the females and 23.2 per cent for the 798 males. However, the groups differed markedly with respect to post-Academy attrition rates. It was determined that 33.3 per cent of the 66 females who completed Academy basic training were no longer in the air traffic management system as of April 1971 whereas only 19.1 per cent of the 613 males (within the sample of 798) who graduated from the Academy were subsequently attrited.

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A COMPARATIVE STUDY OF FEMALE AND MALE AIR TRAFFIC CONTROLLER TRAINEES

I. Introduction.

This report compares aptitudes, ages, pre-FAA experience, training-course performance measures, and post-Academy attrition rates of the 83 women who entered basic air traffic control training at the Federal Aviation Administration's Academy during 20 November 1968 through 27 March 1970 with those of various samples selected from the 3,760 male trainees who entered during the same time period. The opportunity to conduct this study was made possible by the availability of data which the FAA's Civil Aeromedical Institute (CAMI) collected during the 17-month period for the Academy's total input of 3,843 trainees in conjunction with a comprehensive research project aimed at the identification of factors bearing upon training performance.[5 6]

The decision to undertake this comparative study of female and male Air Traffic Control (ATC) trainees was precipitated by the FAA's interest and participation in the Federal Government's overall program to eliminate sex as a discriminating factor in the selection of new employees. It has long been a governmental policy to provide equal employment opportunity in the Federal service to all persons, regardless of race, color, religion, national origin, or sex. This policy was reiterated by President Richard M. Nixon on 8 August 1969 in Executive Order 11478 wherein the head of each department and agency was directed to "establish and maintain an affirmative program of equal employment opportunity" to eliminate all remaining vestiges of discriminatory practices. The study was also prompted by the fact that women have never represented more than a very small proportion of all personnel directly involved in air traffic management. (Because experience is heavily weighted in establishing an applicant's Civil Service eligibility rating, the "best qualified" by normal standards are usually male veterans with experience in military ATC work or as pilots.)[3 4 10 12 13] It was therefore contemplated that comparative analyses of the various types of data available for the 83 females and larger groups of male trainees would yield findings of value to the FAA in its formulation of future recruitment, selection, and training programs.

The assistance of Peter Nelson, Dana Hauserman, and Barbara Mallett in the collection, processing, and/or analysis of the data is gratefully acknowledged.

II. Procedure.

As part of a comprehensive research project,[5 6] various aptitude tests were administered, on an experimental basis, to all but three of the successive incoming classes of the Academy's basic training courses in Terminal Area Traffic Control (TATC), Air Route Air Traffic Control (or En Route), and Flight Service Station (FSS) work during a 17-month period. CAMI was to be provided a report on each trainee at time of entry into the Academy, reflecting types and amounts of pre-employment experience, facility of assignment, the overall eligibility rating (used for selection purposes), pay grade, and other information; the report on each trainee who took the operational CSC ATC Aptitude Test Battery was also to include all part scores and the composite measure of performance.

The vast majority of the trainees arrived at the Aeronautical Center for enrollment in the Academy's TATC, En Route, or FSS course within two weeks after being hired by the FAA. Combined enrollments for the three training courses during the period 20 November 1968 through 27 March 1970 totaled 4,015 of whom 86, or 2.2 per cent, were females. However, 172 cases (including three females) were deleted for all phases of the project due to gross incompleteness of data records. Records for many of the remaining 3,843 trainees were also incomplete but contained data and information sufficient to

warrant inclusion in one or more of the scheduled investigative phases.

Although participation in the experimental testing program was not mandatory, few declined to do so. Only 410 (10.7 per cent) of the 3,843 trainees were not examined and the majority of the 410 were in classes for which testing sessions were cancelled in order to avoid holiday travel conflicts. Generally, each group was examined on the day of arrival at the Academy. No more than three hours could be allocated for each testing session and adherence to training schedules precluded more than one session per class or group. Inasmuch as the overall project specified that the potential of many different types of tests be explored as predictors of training performance, the groups of tests selected for experimental administration were intentionally varied. At least one week, and sometimes two, intervened between incoming groups. Each group was administered only five to seven instruments but periodic modification of the battery ultimately resulted in the collection of response data *on samples of different size for 36 different tests or subtests* (these yielded 41 performance measures).

The validities of the experimentally administered tests and intercorrelations of the scores, background variables, and criterion measures have been previously reported [5 6] for selected samples only. Such correlative data, however, were not computed for the various samples and subsamples involved in the present study.

A. *Criterion Variables.* Academy training officials provided CAMI with an "Evaluation of Performance Record" for each trainee shortly after the graduation date of each class. The evaluation forms for the ARTCC, TATC, and FSS trainees were different in several respects, but each provided grades which permitted derivation of a similar, corresponding measure of performance for each subject, regardless of training option. The summary measure, referred to as the "Combined Academic and Laboratory Grade Average" or "A+L," represented an arithmetical mean of two separate averages: one based on grades of examinations relating to academic materials, instruction, and the like, and the other based on performance grades for simulated air-traffic-control work in the laboratory.

The second major criterion variable was "Pass-Fail Status" (or "P-F") for the training course. Generally, students who failed to successfully complete the course, regardless of reason, were designated as "fails" and graduates as "passes." In some analyses, however, a further distinction was made in regard to the non-graduates, with students whose records indicated "withdrawn in non-failing status" being considered separately from the fail and pass cases.

The third criterion variable, "Retention-Attrition Status," reflected whether the trainee was or was not with the FAA in ATCS work as of 1 April 1971. CAMI test records were compared with an agency magnetic tape record of all personnel within the FAA who, on 1 April 1971, possessed an occupational code of 2152 (denoting the ATCS speciality). Collation procedures determined those individuals still within the air traffic management system on that date; each such case was designated as a "retention." Each of the remaining cases of the CAMI samples was designated as an "attrition." For many of the analyses, however, the attritions were divided into two groups, reflecting either failure in the Academy training course or attrition after having passed the course. Unfortunately, no means were available to determine the month or year in which a "post-Academy attrition" terminated his or her service.

B. *Background Variables.* CAMI administered a lengthy questionnaire to each incoming class of trainees in order to obtain first-hand information relating to each subject's educational background, pre-employment experience, and age at entry into the Academy. Educational level was coded on a 9-point scale, with a code of "1" denoting "no high school diploma," codes "2" through "7" reflecting progressively greater amounts of education, "8" denoting award of a Bachelor's Degree, and "9" indicating a Master's Degree.

In one section of the questionnaire, the trainee was requested to indicate whether he had ever held a license, certificate, or rating as a "pilot" and/or in "air traffic control work" and/or in the field of communications. These are the types of experience which the FAA has traditionally considered most important in the selection of personnel for ATCS training. There were always some students in each Academy group who replied "No" to each of the three areas, while the remainder checked "Yes" for one or more. The

responses provided the basis for assigning each case to one of the eight mutually exclusive categories, ranging from certificated experience in all three fields to one indicating no rating in any area. Analyses were then undertaken to compare the females and males in terms of experience and to assess possible effects of experience upon training performance.

FROM THE QUESTIONNAIRE, SUBJECTS AGES WERE ~~rounded to the nearest birthday at time of entry~~ rounded to the nearest birthday at time of entry into Academy training. Analyses were then scheduled to compare age distributions for females and males and also to relate age to the performance measures of the respective groups.

C. *CSC ATC Aptitude Test Scores.* Scores from the operational CSC Screening Battery were provided by the Regions for about 52 per cent of the 3,843 trainees involved in the overall project. The percentage was lower than expected because almost three-fourths of the entire group indicated on the CAMI Questionnaire that they had been operationally examined with the battery one or more times. Moreover, scores were provided for a much smaller proportion of the Academy training failures than for graduates. The reason why this occurred is unknown but it may have been related to the fact that test records of trainees in each Academy class were usually forwarded several weeks after class graduation date; records of attrited personnel may have been discarded by that time. A matter of great importance, however, is that any bias in the collection of such data would preclude an accurate assessment of the battery's validity for prediction of training-course pass-fail status. We are therefore obliged to presume that analyses accomplished in the present study (and in other phases of the overall project)[5,6] have produced attenuated validity coefficients for the operationally-derived aptitude measures and that correlations involving the latter and age and other variables have also been affected.

Descriptions of the five tests comprising the CSC Aptitude Screening Battery and the manner in which each is weighted for derivation of the Composite Score are presented in Table 1. The Composite CSC Scores only, rather than part scores, were dealt with when establishing

TABLE I. Description of CSC-ATC-Aptitude-Screening-Test Battery.

CSC Subtest	Weight	Description
CSC 24 Computations	1	A highly-speeded test of arithmetic skill. The problems involve simple addition, subtraction, multiplication and division. The aptitude factor is referred to as "numerical facility."
CSC 51 Spatial Patterns	2	A test consisting of two different types of spatial items. In one type, the task is to identify solid figures that can be made from unfolded patterns. In the other type, three different views of an object are presented and the subject must select the correct object from one of four alternatives.
CSC 135 Following Oral Directions	1	In this test the subject must listen carefully to orally-presented directions and information; then discriminate between relevant and irrelevant information in order to proceed toward the proper solution of a series of simple tasks.
CSC 157 Abstract Reasoning and Letter Sequence	2	In the "Abstract Reasoning" portion of the booklet, the task is to indicate which of a series of choices (figures) properly carries out a principle of logical development exhibited by a sequence of figures. In "Letter Sequence" the subject must indicate which of a series of letters properly carries out a principle of logical development exhibited by a sequence of letters.
CSC 540 Air Traffic Problems	1	A highly-speeded test consisting of two parts of thirty items each. In each part, the subject is presented a flight data display for several aircraft and must determine whether certain changes in altitude may be directed without violating a specified time-separation rule.
CSC Composite or Total of Weighted Scores		Sum of the weighted raw scores for each of the five CSC test booklets (i.e., six subtests).

the interrelationships of performance on the battery and variables such as age, experience, attrition-retention status, and other criteria. However, when preparing summary profiles reflecting the performance of females relative to males, the means of scores were computed for each of the five tests of the CSC Battery, the CSC Composite, and also for each of the experimentally administered tests.

Many of the test records forwarded to CAMI included a CSC Composite Score but not part scores. This explains the otherwise unexpected inconsistency in the numbers of cases involved in some of the analyses.

D. *The Experimentally Administered Tests.* Since the basic aim of the overall research project was to explore the potential of many tests for improving the aptitude screening of ATCS applicants, groups of tests selected for experimental administration were intentionally changed from time to time. A few incoming classes, involving 870 trainees, were experimentally administered the complete CSC Battery, together with one to three additional tests. Over 95 per cent of these 870 trainees claimed to have been assessed with the CSC Battery upon entry into the FAA and records to this effect (though not always complete with part scores) were forwarded to CAMI for 64.8 per cent of them.

All other classes of the 17-month period were administered five to seven of the commercially published or FAA-developed instruments described in Tables 2 and 3. As mentioned earlier, periodic modification of the experimental batteries ultimately led to the collection of data on samples of varying size for 36 different tests or subtests, yielding a total of 41 performance measures or scales.

E. *Samples.* The present study consisted of three investigative phases. In Phase I, two analyses were accomplished which involved the entire group of 3,843 trainees. The first analysis was directed toward establishing the number and proportion of females and males in each of the three training options (i.e., ARTCC, TATC, and FSS options). The other focused upon a comparison of the 83 females and 3,760 males in terms of Academy attrition rate by age group.

In Phase II, numerous analyses [8] were undertaken to compare the females with a selected sample of 798 males with regard to educational level, experience background, age, operational CSC Test Scores, Academy pass-fail status, and post-Academy retention-attrition status. Eighty of the 83 females entered training at a pay grade (or General Schedule level) of GS–7, which was the normal entry level. The remaining three were GS–9's, who presumably qualified for appointment to training at the higher pay grade on the basis of specialized pre-FAA ATC-related experience. Inasmuch as the total number of female cases was only 83, and the deletion of the three GS–9's would have rendered the sample even smaller, the GS level of each female was disregarded in all analyses. In the selection of male cases, however, only those of GS–7 level were considered. The 798 males comprising the sample against which the 83 females were compared in Phase II represented the total number of men who entered Academy ATCS training at the GS–7 level during 8 May 1969 through 31 July 1969, a period roughly midway between the first and last testing session of the 17-month test period.

Phase III consisted of a series of analyses in which the females were compared with GS–7 level male trainees in terms of mean performance on each of the experimentally administered tests. Due to successive modification of the experimental batteries, however, the sizes of the samples were quite variable for both the males and females. Many of the tests were administered to groups which included appreciable numbers of females, but some were administered to several classes for which the total number of women was less than 10. In making each comparison, the maximum number of female cases available was used, whereas each sample of males usually represented only a portion of the total number of men examined with a specific test.

III. Results and Discussion.

PHASE I

A. *Training-Course Attrition Rates of Total Female and Male Groups.* Slightly over 65 per cent of the 83 female subjects were enrollees of the Academy's basic training course in En Route or ARTCC procedures, 24.1 per cent attended the basic TATC or Terminal course, and the remaining 10.8 per cent took initial FSS training (see Table 4). Of the 3,760 males, 70.4 per cent were ARTCC students, 22.8 per cent attended the

TABLE 2. Descriptions of tests administered experimentally to substantially large proportions of both the female and male ATCS Trainees.

Tests for Which Comparative Results Are Presented in Figure 8.	
Press Test (Three Parts)	A speeded test in which the subject responds to words or dots representing four colors by writing the letters R, B, G, and Y. The subject responds to: the words "red", "blue", "green", or "yellow" (Part I); dots colored red, blue, green, or yellow (Part II); or the color of ink in which the words "red", "blue", "green", or "yellow" are printed (Part III).
CAMI Directional Headings Test (Three Parts)	A highly speeded test requiring the interpretation of letters, symbols and degrees in order to establish true headings (Part I), exact opposites of true headings (Part II), and exact opposites of true headings under conditions of aural distraction (Part III).
CAMI Symbol-to-Digit Test	A highly speeded test of decoding symbols to digits in accordance with a nine-unit key.
WAIS Digit-to-Symbol	One of 11 subtests of the Wechsler Adult Intelligence Scale. A highly speeded test of encoding digits to symbols in accordance with a nine-unit key.
A. I. R. Locating Data	A speeded perceptual-precision task in which the examinee is provided a data display resembling that of a series of flight progress strips within which he must quickly locate blocks of data containing specific groups of numbers and/or symbols. (Developed by American Institute for Research.)
Tests for Which Comparative Results Are Presented in Figure 9.	
Brown-Carlsen Listening Comprehension	A five part test in which each item or problem is presented orally.
A-Immediate Recall	A test of immediate recall of the order in which numbers, letters or words are presented in each of several items.
B-Following Directions	Following oral directions in addition, subtraction, underlining, and/or circling of numbers and letters presented in a display.
C-Recognizing Transitions	Measures ability to recognize whether a sentence is of an introductory, transitional, or concluding nature.
D-Recognizing Word Meanings	Selection of best synonyms for words in accordance with the context in which they are used in specific sentences.
E-Lecture Comprehension	Provides a measure of delayed recall. The subject's task is to recall facts and information presented in a 12-minute lecture.

TABLE 3. Descriptions of tests administered on an experimental basis to relatively small numbers of the female and male ATCS Trainees (see Table 6).

California Test of Mental Maturity (CTMM)	Four of the 12 subtests comprising the CTMM test booklet were administered to selected classes.
CTMM Figure Analogies	In each item, the subject must recognize the relationship between a pair of drawings (objects) in order to identify, by analogy, one of four alternatives as being similarly related to a third drawing.
CTMM Inference	Comprehension of statements presenting premises used in the derivation of logical conclusions.
CTMM Coins	Involves the mental manipulations of interrelated amounts of money and numbers of coins.
CTMM Arithmetic	Solving of word-presented arithmetic problems.
Differential Aptitude Test Battery (DAT)	A battery of eight different aptitude measures. Three of the tests were administered to selected classes.
DAT Space Relations	The task is to visualize three-dimensional forms or objects that can be made from unfolded patterns.
DAT Abstract Reasoning	Indicating which of a series of choices (figures) properly carries out a principle of logical development exhibited by a sequence of figures.
DAT Numerical Ability	A test of general arithmetic computational skill.
Dailey Technical and Scholastic Test (TST)	An omnibus test measuring technical and scholastic knowledge as well as general aptitude for achievement in the physical sciences. Certain items scattered among 150 are scored to yield measures of knowledge and/or skill in areas of vocabulary, algebra, arithmetic, electricity, science, mechanics, and electronics.
Dailey Spatial Visualization Test	The subject must visualize three-dimensional figures from a flat unfolded pattern in order to match certain lines, angles, and parts of each presented pattern with corresponding aspects of the constructed figure.
Vocational Educational Test Battery (VETB)	Six tests providing measures of arithmetic reasoning, abstract reasoning, mechanical reasoning, two-dimensional visualization, three-dimensional visualization, and reading comprehension.

TATC course, and 6.8 per cent were FSS trainees. Although the total number of females was rather small, the male-female proportions per each training option are remarkably similar; none of the differences proved to be statistically significant. However, women were vastly underrepresented in each of the training options. As shown in the lower portion on Table 4, the females comprised only 2.0 to 3.4 per cent of the various input groups.

The number and proportion of trainees in both the female and male groups who failed to successfully complete Academy basic training are presented in Figure 1, which also reflects the influence of age upon performance. Before considering age, however, one should note the degree of similarity between the attrition rates of the groups. Some 16.9 per cent of the females, compared to 16.6 per cent of the males, were attrited with failing grades. For both groups, 3.6 percent "withdrew in non-failing status."

Although not tabulated or graphed, the women, as a group, scored significantly *lower* ($p<.05$) than the men on examinations relating to academic and instructional materials, whereas their mean performance rating on laboratory-simulated air traffic control problems was somewhat *higher*, but not significantly so, than that of the men. Such group differences, however, had no differential effects on the overall attrition rates for the two groups.

The non-graduates of both groups totaled 777, representing an overall attrition rate of 20.2 per cent for these 3,843 trainees of recent years. A point of more than incidental interest is that this attrition rate is substantially lower than the rates of 28 to 33 per cent which prevailed during 1960 through 1963—before operational implementation of the CSC Aptitude Screening Battery.[11 13] This finding suggests that current screening procedures are substantially better than those used prior to 1964.

B. *Academy Failures by Age Group.* Returning again to Figure 1, it should be noted that the majority of the trainees were relatively young. The 55 females who were 30 years of age or younger represented 66.3 per cent of the sample of 83 whereas the 2,652 males of the same age category represented 70.5 per cent of the sample of 3,760. In each sample, the training-course graduation rate was highest for the youngest group (i.e., age 30 and less), somewhat lower for those 31 to 35 years old, and significantly lower for those who entered after reaching their 36th birthday.

The implications of age upon performance tend to be conveyed even more clearly when expressed in terms of failure rate, rather than graduation

TABLE 4. Percentage of females and males in each training option.

	En Route Trainees		Terminal Trainees		FSS Trainees		Combined (All Options)	
	N	%	N	%	N	%	N	%
Females	54	65.1	20	24.1	9	10.8	83	100.0
Males	2646	70.4	859	22.8	255	6.8	3760	100.0
Total	2700	70.2	879	22.9	264	6.9	3843	100.0
Percentage of trainees represented by females:		2.0		2.3		3.4		2.2

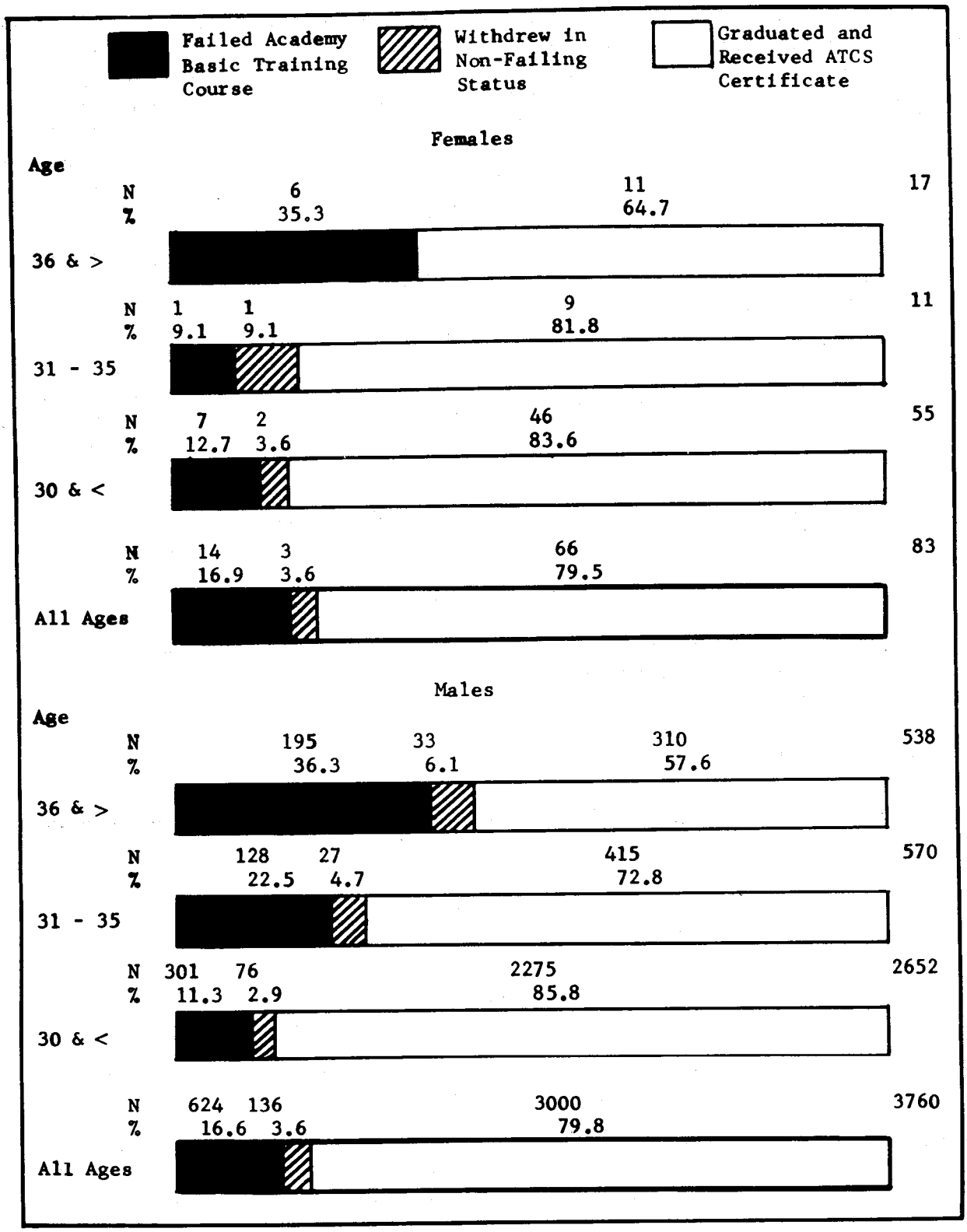


FIGURE 1. Proportion of students by sex and age group who failed, withdrew in non-failing status, or successfully completed Academy basic training in TATC, ARTCC, or FSS procedures during 20 November 1968 through 27 March 1970.

rate, for each age group. For example, slightly over 35 per cent of the 17 oldest females and 36.3 per cent of the 538 oldest males failed to successfully complete Academy basic training. In contrast, the failures represented only 12.7 per cent of the 55 females of age 30 and less and only 11.3 per cent of the 2,652 youngest males, Such findings are not only comparable for the two samples; they also closely parallel those stemming from a number of previous studies [5 11 13] and thus provide further justification for proposals to limit the recruiting of personnel for ATCS training to applicants under 35 years of age—regardless of pre-FAA ATC-related experience.

PHASE II

The analyses accomplished in Phase II of the study involved a comparison of the 83 females with the 798 males of the selected sample relative to educational level, Academy training-course performance grades, age, experience background, CSC Aptitude Test Scores, and also the extent to which each such variable was related to Academy pass-fail status and post-Academy retention-attrition status. Before examining these analyses, however, the groups should first be compared in terms of attrition rates while at the Academy and for subsequent training extending up to 1 April 1971.

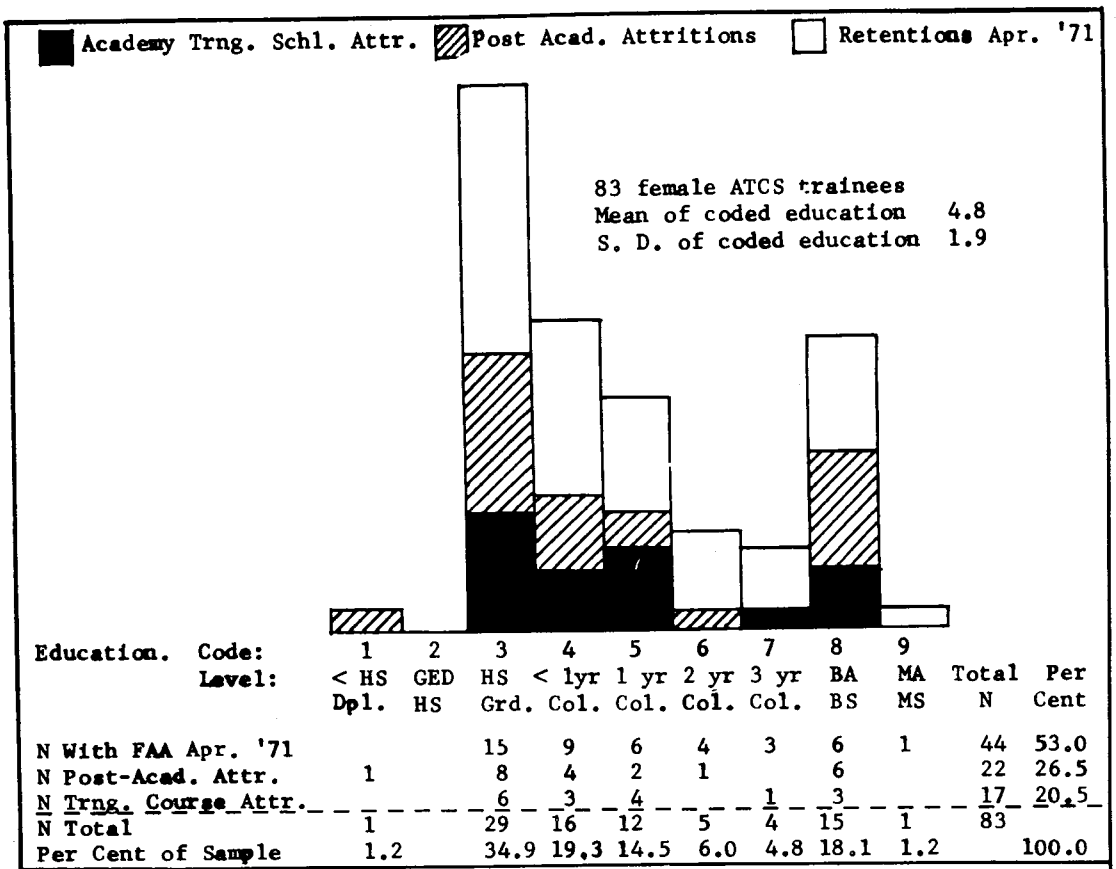
A. *Training Attrition Rates.* Academy non-graduates, including "failures" and "'withdrawals in non-failing status," represented 20.5 per cent of the 83 females and 23.2 per cent of the 798 males (see Figure 2). The latter attrition rate is higher than the 20.2 per cent previously established for the entire group of 3,760 males but neither percentage is significantly higher than the 20.5 found for the females. In contrast, the post-Academy attrition rate of 26.5 per cent for the females is significantly higher ($p<.01$) than the 14.7 per cent obtained for the males. Although only 53 per cent (N=44) of the 83 women were still in FAA ATC work as of 1 April 1972, compared to 62.2 per cent (N=496) of the 798 men, this difference was not statistically significant.

It should be mentioned that the records utilized for follow-up purposes were last updated on 1 April 1971 and that inasmuch as the subjects entered the Academy at different times, the post-Academy training periods ranged from approximately 10 to 27 months for the females whereas the range for the males was 18 to 20 months. However, the average length of the post-Academy training period was almost the same for the two groups. It was 18½ months for the non-attrited females and 19 months for the non-attrited males. The authors were therefore inclined to consider the difference between the post-Academy attrition rates (26.5 per cent for females vs. 14.7 per cent for males) as one of the most important findings of the entire study. Inasmuch as the women evidently performed comparably with the men while at the Academy, there is need for further research, beyond the scope of the present study, to determine the factors (e.g., the basis for volitional attrition) underlying their relatively high post-Academy attrition rate.

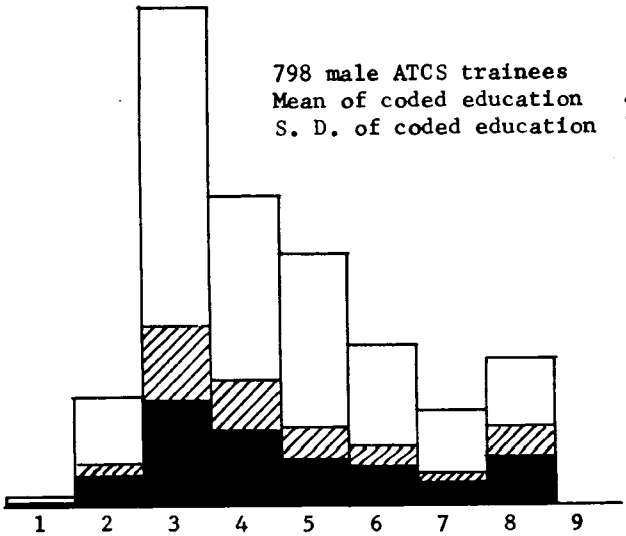
B. *Educational Level.* Figure 2 illustrates that the educational level of the females was generally higher than that of most males, but the analysis failed to yield any evidence to warrant an assumption that education beyond high school should be required for entry into ATCS training. In fact, some evidence to the contrary was obtained. For example, 16 females (19.3 per cent) possessed a college degree but 9 of the 16 were attrited either at the Academy or in subsquent phases of training. The attrition rate of 56.2 per cent for this relatively well-educated subgroup was higher (though not significantly) than the rate of 47.0 per cent established for the complete female sample. Similar findings were obtained for the males. Although only 73 (9.1 per cent) of the 798 males were college graduates, 26 of them failed Academy training and an additional 14 were eliminated during later stages of training, resulting in an attrition rate of 54.8 per cent, which was significantly above the overall rate of 37.9 per cent for the 798.

Thirty females, representing 36.1 per cent of the 83, possessed no formal education beyond high school and 15 of them were still with the FAA as of 1 April 1971, yielding a retention rate approaching that established with the entire sample. Three hundred and fifteen, or 39.5 per cent, of the males had no more than a high school education but 64.4 per cent of the 315 were "retentions." The latter percentage is higher (but not significantly) than that (of 62.2) obtained for the total sample of 798.

In view of these findings, an additional analysis (not presented in any table or figure) was accom-

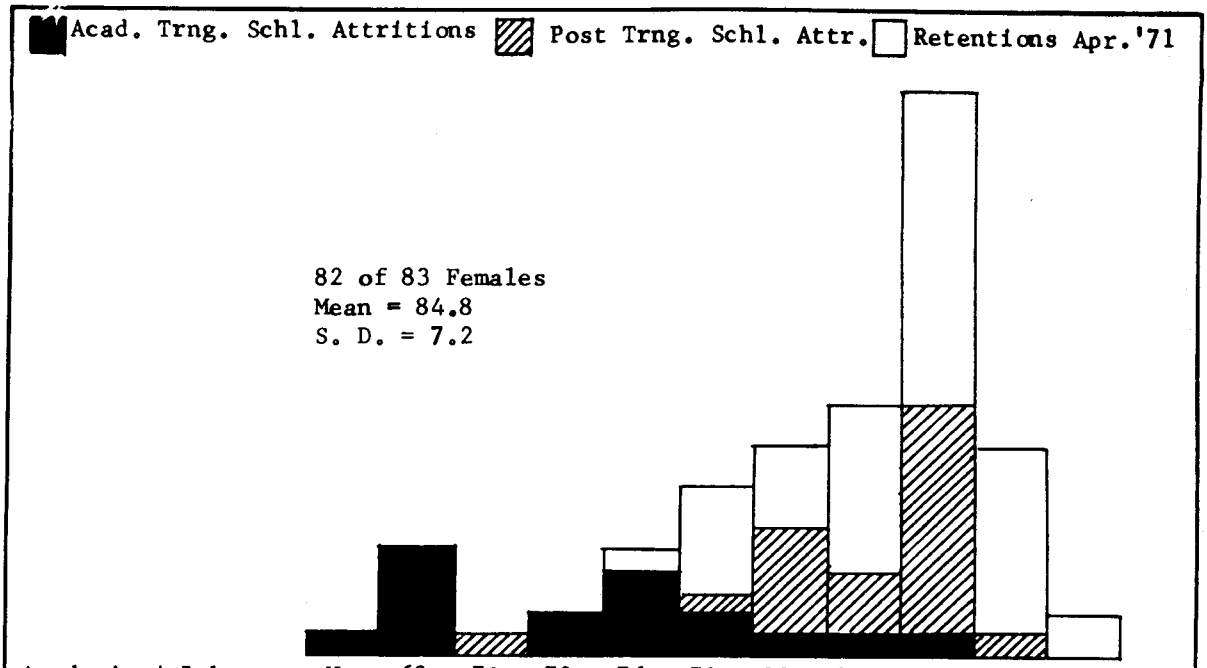


Education. Code:	1	2	3	4	5	6	7	8	9		
Level:	< HS Dpl.	GED HS	HS Grd.	< 1yr Col.	1 yr Col.	2 yr Col.	3 yr Col.	BA BS	MA MS	Total N	Per Cent
N With FAA Apr. '71			15	9	6	4	3	6	1	44	53.0
N Post-Acad. Attr.	1		8	4	2	1		6		22	26.5
N Trng. Course Attr.			6	3	4		1	3		17	20.5
N Total	1		29	16	12	5	4	15	1	83	
Per Cent of Sample	1.2		34.9	19.3	14.5	6.0	4.8	18.1	1.2		100.0

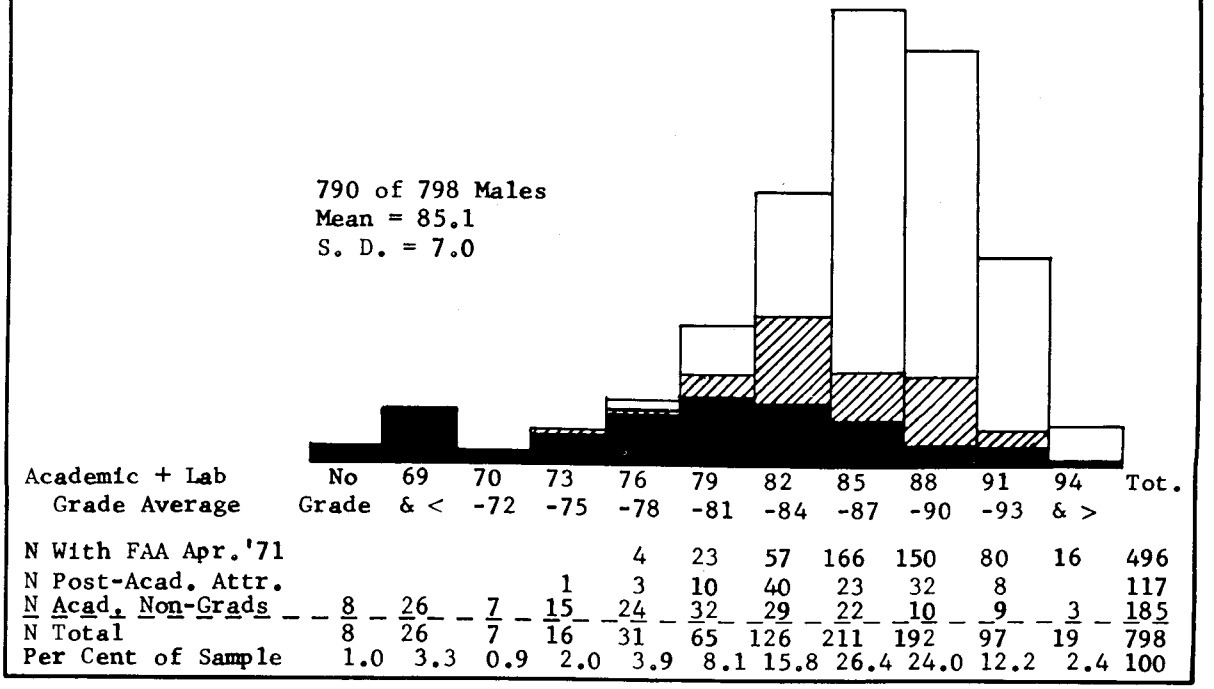


Education. Code:	1	2	3	4	5	6	7	8	9		
Level:	< HS Dpl.	GED HS	HS Grd.	< 1yr Col.	1 yr Col.	2 yr Col.	3 yr Col.	BA BS	MA MS	Total N	Per Cent
N With FAA Apr. '71	2	34	167	93	86	49	32	33		496	62.2
N Post-Acad. Attr.		6	38	25	16	13	5	14		117	14.7
N Trng. Course Attr.	1	15	52	38	24	18	11	26		185	23.2
N Total	3	55	257	156	126	80	48	73		798	
Per Cent of Sample	0.4	6.9	32.2	19.6	15.8	10.0	6.0	9.1			100.0

FIGURE 2. Educational levels of 83 female and 798 male ATCS trainees.



Academic + Lab Grade Average	No Grade	69 & <	70 -72	73 -75	76 -78	79 -81	82 -84	85 -87	88 -90	91 -93	94 & >	Tot.
N With FAA Apr.'71					1	5	4	8	15	9	2	44
N Post-Acad. Attr.			1			1	5	3	11	1		22
N Acad. Non-Grads	1	5		2	4	2	1	1	1			17
N Total	1	5	1	2	5	8	10	12	27	10	2	83
Per Cent of Sample	1.2	6.0	1.2	2.4	6.0	9.6	12.1	14.5	32.5	12.1	2.4	100



Academic + Lab Grade Average	No Grade	69 & <	70 -72	73 -75	76 -78	79 -81	82 -84	85 -87	88 -90	91 -93	94 & >	Tot.
N With FAA Apr.'71					4	23	57	166	150	80	16	496
N Post-Acad. Attr.				1	3	10	40	23	32	8		117
N Acad. Non-Grads	8	26	7	15	24	32	29	22	10	9	3	185
N Total	8	26	7	16	31	65	126	211	192	97	19	798
Per Cent of Sample	1.0	3.3	0.9	2.0	3.9	8.1	15.8	26.4	24.0	12.2	2.4	100

FIGURE 3. Distributions of "Academic + Laboratory" (or "A + L") training course grade average for 82 of 83 female and 790 of 798 male ATCS trainees.

plished for the male sample alone. Only 43.8 per cent (N=32) of the 73 male college graduates, 67.6 per cent (N=277) of the 410 males who had some college education but no degree, and 63.8 per cent (N=201) of the 315 who never attended college had held pre-FAA ratings in either ATC work, as a pilot, in communications work, or in two or all three of the latter areas. In other words, the group of college graduates was significantly less experienced ($p<.01$) than either of the other groups. Moreover, an examination of the trainees' records and their responses to the CAMI Questionnaire indicated that most of the non-experienced college graduates established their eligibility for entry into FAA training on the basis of education and/or aptitude-screening-test measures.

As will be noted in later sections of this report, education was negligibly correlated with every criterion measure utilized in the study. Such findings are consistent with those obtained in previous studies.[2 4 12]

C. *Academic and Laboratory Grade Average.* Distributions of the "A+L Grades" for the 83 females and 798 males are shown in Figure 3. It should be reemphasized that the A+L Grade is a CAMI-derived measure representing the mean of two averages, one based on scores of examinations relating to academic materials and instruction, and the other based on all laboratory performance grades. None of these is utilized by training officials as a criterion measure. Instead, graduation from the Academy requires that the trainee attain satisfactory grades of at least 70 in each of several different academic areas and in all phases of laboratory work. As many as three "retakes" of tests relating to specific areas are sometimes permitted but inability to ultimately master even one area can lead to elimination from the training program. Thus, the CAMI-computed A+L Grades for some of the training-course non-graduates are higher than those of many training-course graduates.

With the exception of the relatively high proportion of female cases represented in the A+L Grade interval of "88 to 90," the distributions of the two samples are rather similar in shape, or contour. Both are negatively skewed and about three-fourths of the cases in each sample are within four of the 11 three-point intervals (from 82 through 93). The mean A+L Grade of 84.8 for the females is not significantly different from the 85.1 for the males, and the standard deviations are also highly comparable.

D. *Chronological Age.* The ages of the females averaged 29.5 years (range: 21–48) whereas the ages of the 798 males (range: 20–52) averaged 28.4. The mean difference was not statistically significant. The distributions of age for the two groups appear in Figure 4. By adding the frequencies shown for the four lowest age brackets, it can be determined that 65 per cent (N=54) of the females and 66 per cent (N=526) of the males were less than 30 years old at time of entry into training. Each distribution is highly skewed, with about one-third of the cases in each sample being distributed among the remaining nine older age categories. As may be noted, however, the distribution for the males illustrates that a relatively small proportion, 15.5 per cent, of the latter were over 33 years of age. In contrast, 26.5 per cent of the females were age 34 or older. The difference between the proportions was statistically significant ($p<.01$).

Further analysis of the data shown in Figure 4 indicated, as did Figure 1, that age was inversely related to success in ATCS training. For example, 54 per cent (N=67) of the 124 men of age 34 and older were eliminated from training, while at the Academy or afterwards, whereas only 34.9 per cent (N=235) of their younger colleagues were attrited; the difference was statistically significant at the .01 level. Almost 64 per cent (N=14) of the 22 older females and only 41 per cent (N=25) of the 61 younger women were attrited at some stage of training prior to 1 April 1971. The latter difference, though even greater than that based on the sample of males, was not significant ($p<.10$) due to the small number of cases involved. Nonetheless, the findings obtained with both samples further illustrate that selectees over 34 years of age are much more likely to be unsuccessful in achieving journeyman ATCS status than their younger colleagues—regardless of experience background.

E. *Pre-FAA ATC-Related Experience.* Subjects who indicated on the CAMI Questionnaire that they possessed no certificated ATC-related experience represented 54.2 per cent of the females and 36.1 per cent of the male sample; the difference was significant at the .01 level.

These and other findings in Figure 5 are based on an analysis, described earlier, in which each case of each sample was assigned to only one of six mutually exclusive categories. Only in the "No Rated Experience" category did the proportion of the female sample exceed that of the males. However, the two groups were similar in that, when an individual possessed a rating or certificate, it was usually as an "ATC Only" or as a pilot who also held some sort of communications rating.

Slightly over 24 per cent of the females and 26 per cent of the males indicated they had certificated experience both as a pilot and in communications. Some 15.6 per cent of the females and 22.9 per cent of the males stated they held an "ATC Rating Only." The cases in the remaining experience categories accounted for only 6 per cent of the female sample and less than 15 per cent of the males.

Further inspection and analysis of the data presented in Figure 5 will reveal that the majority of the males and females who were eventually attrited either possessed no rated experience of any type or ratings which did not directly pertain to ATC work. For example, 125 of the 302 attrited males possessed no related experience and an additional 87 were categorized under "Pilot and Communications"; this total of 212 represented 70.2 per cent of the attritions of the male sample. It should also be noted that the attrited female cases within the "No Rated Experience" and "Pilot and Communications" categories add to 31, accounting for almost 80 per cent of the 39 women who terminated their ATCS career before 1 April 1971.

Such findings are in general agreement with those of previous studies [12 13 14] based on samples recruited prior to 1964. In this earlier research it was determined that every type of experience other than work directly involving air traffic control (i.e., radar or VFR control) was negligibly, and sometimes inversely, related to measures of training performance. This was particularly true with respect to evaluations of pilot experience. Also, assessments of communications work have never correlated appreciably with any criteria other than the laboratory performance grades of FSS trainees. Although a number of changes in the procedures for evaluation of preemployment experience have occurred since 1964, the results obtained in the present study with recently recruited groups of trainees tend to indicate that the experience assessment methods may need further revision.

F. *Operational CSC Aptitude Test Screening Scores.* Records forwarded to CAMI by Regional officials included performance scores on the CSC Aptitude Screening Battery for 59 (or 71.1 per cent) of the females and 512 (or 64.2 per cent) of the males; the difference between proportions was not statistically significant. However, findings regarding the CSC test measures should not be taken at face value because, as discussed earlier, scores were not forwarded for many of the trainees who claimed to have been operationally examined. Inasmuch as this was particularly true with respect to the training-course failures, it was impossible to reliably estimate the true validity of the battery for prediction of the criterion measures for either the males or females involved in this study.

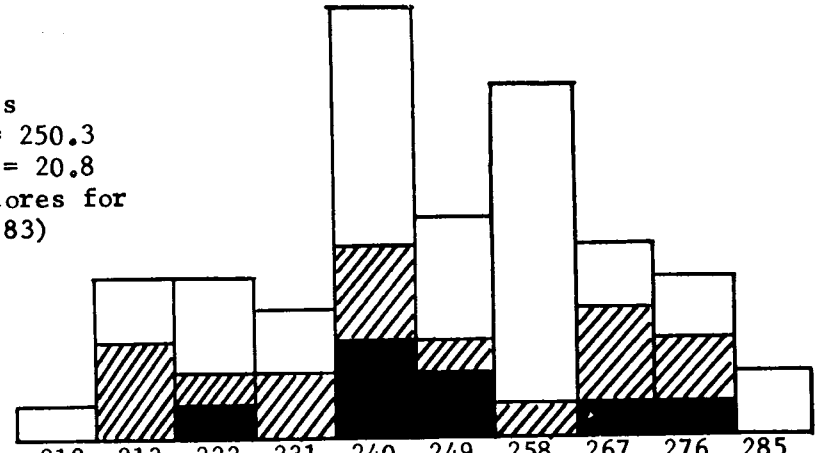
The CSC Score distributions for the two samples are shown in Figure 6. Virtually all of the reported scores were above 210, which is considered as minimally qualifying on the battery, and some of the trainees in each sample scored over 285—a score which was attained by less than one per cent of the pre-1964 students who participated in the original validation research.[5 6]

The irregularity of contour in the distribution of scores for the females is probably due to the small number of cases comprising the sample. In contrast, the distribution for the 512 males more closely resembles a Gaussian, or "normal," curve. The mean score of 250.3 for the females did not differ significantly from the mean of 246.7 obtained for the males. We estimate that no more than 12 per cent of the *general population* would score above 210 on the battery and that less than 3 per cent would attain scores higher than 245.

A point of salient interest is that the attrited cases in each sample are distributed throughout the entire range of obtained CSC Test Scores. If bias had not occured in the collection of the test performance data or if the scores had been available for proportionately as many Academy training-course failures as passes, the results might have been contrastingly different—but nevertheless grossly attenuated due to the exceptionally high and narrow range of aptitude scores from which all these trainees were selected.

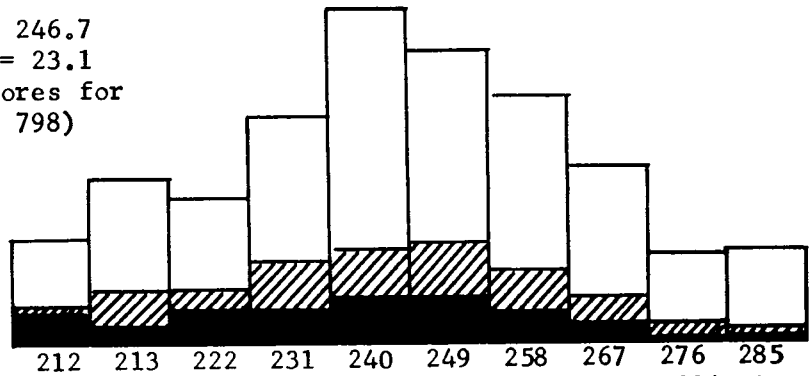
■ Academy Attritions ▨ Post-Academy Attritions □ Retentions as of Apr.'71

Females
Mean = 250.3
S. D. = 20.8
(No scores for 24 of 83)



Operational CSC ATC Test Score	212 & <	213 -221	222 -230	231 -239	240 -248	249 -257	258 -266	267 -275	276 -284	285 & >	Total
N With FAA Apr.'71	1	2	3	2	7	4	10	2	2	2	35
% of Grp W/Scores	1.7	3.4	5.1	3.4	11.9	6.8	17.0	3.4	3.4	3.4	59.3
N Post-Acad. Attr.		3	1	2	3	1	1	3	2		16
% of Grp W/Scores		5.1	1.7	3.4	5.1	1.7	1.7	5.1	3.4		27.1
N Acad. Non-Grads			1		3	2		1	1		8
% of Grp W/Scores			1.7		5.1	3.4		1.7	1.7		13.6
N Total	1	5	5	4	13	7	11	6	5	2	59
% of Scored Group	1.7	8.5	8.5	6.8	22.0	11.9	18.6	10.2	8.5	3.4	100.0

Males
Mean = 246.7
S. D. = 23.1
(No scores for 286 of 798)



Operational CSC ATC Test Score	212 & <	213 -221	222 -230	231 -239	240 -248	249 -257	258 -266	267 -275	276 -284	285 & >	Total
N With FAA Apr.'71	19	31	25	40	66	52	49	36	19	22	359
% of Grp W/Scores	3.7	6.1	4.9	7.8	12.9	10.2	9.6	7.0	3.7	4.3	70.1
N Post-Acad. Attr.	2	9	5	13	14	13	11	7	4	1	79
% of Grp W/Scores	0.4	1.8	1.0	2.5	2.7	2.5	2.2	1.4	0.8	0.2	15.4
N Acad. Non-Grads	8	5	9	9	12	15	8	5	1	2	74
% of Grp W/Scores	1.6	1.0	1.8	1.8	2.3	2.9	1.6	1.0	0.2	0.4	14.5
N Total	29	45	39	62	92	80	68	48	24	25	512
% of Scored Group	5.7	8.8	7.6	12.1	18.0	15.6	13.3	9.4	4.7	4.9	100.0

FIGURE 6. Distributions of operationally derived CSC ATC Aptitude Test scores which were available for 59 of 83 female and 512 of 798 male ATCS trainees.

TABLE 5. Intercorrelations of variables involved in analyses accomplished in phase II of the study.

	Females Max. N / Mean / S.D.	Males Max. N / Mean / S.D.	Intercorrelations: Level of Education (Female / Male)	Oper. CSC ATC Test Score (Female / Male)	Rel. Exp. vs. No Exp.+ (Female / Male)	Acad.+Lab Training Grade (Female / Male)	Academy Pass/Fail Status+ (Female / Male)	Post-Acad. Retention or Attrition+ (Female / Male)
Chron. Age	83 29.5 7.0	798 28.4 5.8	-.20 / -.01	-.03 / -.08	.04 / -.02	-.09 / -.15*	-.13 / -.22*	-.05 / -.18*
Education	83 4.8 1.9	798 4.4 1.7		.34* / .17*	-.13 / -.07	-.01 / .03	.01 / -.05	.02 / -.06
Oper. CSC	59 250.3 20.8	512 246.7 23.1			-.22 / -.23*	.08 / .12*	-.04 / .10*	.08 / .08
Experience N-With Exp. N-No Exp.	38 45	510 288				.14 / .09*	.11 / .09*	-.01 / .09*
Acad.+Lab	82 84.8 7.2	790 85.1 7.0					.69* / .53*	.43* / .44*
Pass/Fail N-Pass Acad. N-Fail Acad.	66 17	613 185						
Ret./Attrit. Tot. N W/FAA Tot. N Attrited	44 39	496 302						

* Significant at less than the .05 level.

\+ A point biserial correlation was computed between this and each continuous variable, and a phi coefficient where another dichotomous variable was involved.

Moreover, regardless of the effectiveness achieved in aptitude screening, it is likely that there will always be a substantial portion of trainees in every sizable group who will be attrited from training due to a variety of other reasons. Consequently, a distribution of attrited cases throughout the restricted range of aptitudes, such as picted in Figure 6, should be expected.

G. *Interrelationships of Variables.* A matrix of intercorrelations of the background variables, the CSC Test Scores, and training performance measures of the 83 females and 798 males appears as Table 5.

Many of the correlations were not of sufficient magnitude to be statistically significant and the differences between corresponding coefficients for the two samples were generally rather small; only one such difference was significant. The latter pertained to the correlations between the CAMI-derived "Academic + Laboratory Grade Average" and "Pass-Fail Status" which was .69 for the sample of females and .53 for the males.

Several other differences between the two groups were substantial yet not statistically significant. For example, the correlation (or "r") between level of education and age was −.20 for the females and only −.01 for the males. The mean age (27.1) of the 16 college graduates in the female sample was significantly lower ($p<.05$) than that of the remaining 67 women (30.1 years), whereas the mean age of the 73 male college graduates (28.3 years) was almost identical to that (28.6) obtained for the 725 men who possessed no college degree. It may be recalled from the previous discussion that the mean age of 29.5 years for the entire group of females was not significantly higher than the 28.4 obtained for the 798 males and that the average educational level of the females was only slightly above that of the males.

Each sample yielded a significant and positive correlation between Coded Educational Level and Composite CSC Test Score; the "r" was .34 for the females and .17 for the males. Due to the small number of females for whom CSC Scores were available (N=59), the difference between the two coefficients was not statistically significant. A supplemental analyses revealed that the CSC Scores forwarded for 43 of the 73 males who possessed college degrees averaged 255.7 which proved to be significantly higher than the mean of 245.9 based on scores available for 469 of the 725 male trainees of lower educational level. Similarly, the scores provided for 14 of the 16 females with college degrees averaged 262.4, significantly higher than the 246.5 based on data for 45 of the 67 remaining females but not significantly above the 255.7 obtained for the male graduates.

PHASE III

The analyses accomplished in Phase III of the study involved comparison of the females and males in terms of performance on various aptitude tests which CAMI administered on an experimental basis as the subjects entered Academy ATCS training. For reasons described earlier, it was possible to examine each incoming class with only five to seven instruments. However, successive changes in the groups of tests selected for administration ultimately resulted in the collection of performance data, *on samples of varying size*, for 36 different tests or subtests.

A. *Tests Administered to Exceptionally Small Groups of Women.* Because many of the instru-

TABLE 6. Means and standard deviation for tests administered experimentally to relatively small numbers of female and male ATCS Trainees.

Test, Subtest, or Scale	Female Trainees N	Mean	S.D.*	Male Trainees N	Mean	S.D.
Calif. Test of Mental Maturity						
CTMM-7, Figure Analogies	5	8.8		221	7.4	1.8
CTMM-8, Inference	5	13.8		221	12.3	1.7
CTMM-10, Coins	5	10.2		221	8.9	3.3
CTMM-11, Arithmetic	4	7.3		179	9.4	2.7
Differential Aptitude Test						
DAT Space Relations	5	73.0		222	69.9	16.5
DAT Abstract Reasoning	5	41.2		222	38.6	6.0
DAT Numerical Ability	5	24.4		222	26.0	8.1
Dailey Technical & Schol. Test						
TST Vocabulary	7	23.0	3.5	73	22.1	4.1
TST Algebra	7	7.7	3.4	73	8.1	3.7
TST Arithmetic	7	23.3	4.2	73	25.0	3.5
TST Electricity	7	5.1	1.2	73	9.7	2.9
TST Science	7	7.0	1.6	73	9.5	3.0
TST Mechanics	7	13.3	2.4	73	23.4	4.4
TST Electronics	7	3.7	1.4	73	6.7	3.4
Dailey Spatial Visualization	9	26.2	4.3	166	24.4	4.3
Vocational Educational Test						
VETB Arithmetic Reasoning	3	13.3		66	13.1	2.8
VETP Abstract Reasoning	3	7.3		66	11.3	2.2
VETb Mechanical Reasoning	3	11.0		66	16.2	2.9
VETB Two Dimensional Visual.	3	8.0		66	13.8	4.4
VETB Three Dimensional Visual.	3	12.0		66	11.8	2.7
VETB Reading Comprehension	3	44.7		66	40.8	5.7

*Although of questioned reliability, standard deviations were computed for samples consisting of seven to nine cases, but were omitted for smaller samples.

ments were administered to only two or three of the 39 Academy classes, the female cases for 21 of the test measures numbered less than ten. The means and standard deviations (S.D.'s) of scores on each of these 21 tests appear in Table 6 for all available female cases and for all male trainees of GS–7 level who were assessed with the instruments. For each of the 21 variables, the number of female cases is admittedly too small to permit a reliable assessment of sex differences. Moreover, the samples within each sex group are not mutually exclusive; they overlap considerably. Nevertheless, it is of interest to note that the means of the women are higher than those of the men on 10 of the 21 variables—a number which would be expected on a "chance" basis.

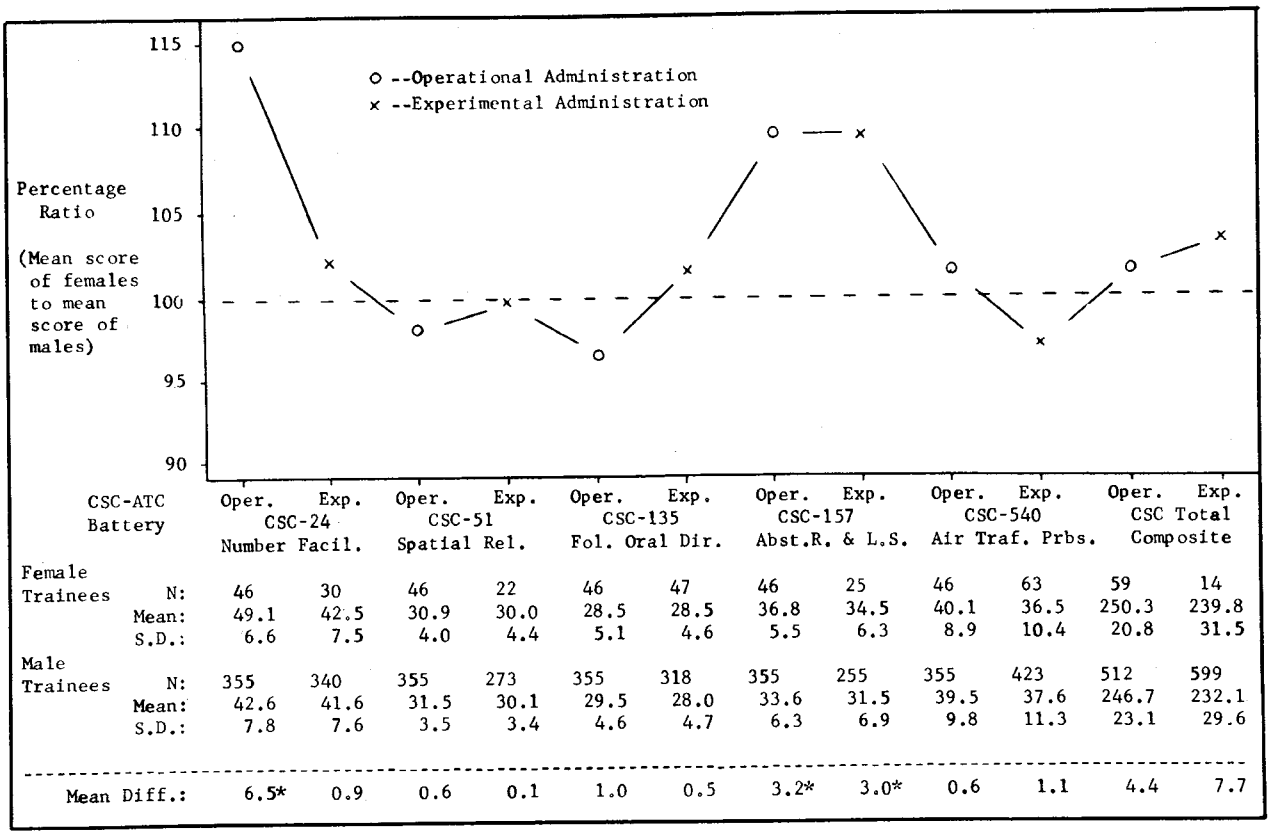
Relative to the standard deviation (S.D.) of scores obtained for the male trainees, the greatest mean performance difference in favor of the females pertains to CTMM Inference. Next in order are those pertaining to CTMM Analogies, followed by VETB Reading Comprehension, DAT Abstract Reasoning, and the Dailey Spatial Visualization Test. The women also scored higher than the men on five other tests or subtests but in each instance the mean difference is so small, relative to the S.D. of the males, as to be inconsequential.

On TST Mechanics, the mean score of 13.3 for the females was 2.3 S.D. units below that of the males. Similarly, their mean scores on both VETB Abstract Reasoning and VETB Mechanical Reasoning are about 1.8 S.D. units lower than those of the men. Females also experienced considerably more difficulty than the men on VETB Two-Dimensional Visualization and TST Electricity. Succinctly, their mean differences on all the latter five were much greater, in terms of the S.D.'s based on the male samples, than for the tests on which they performed better than the males. Differences pertaining to the remaining six tests listed in Table 6 also favored the males but each difference was comparatively small.

B. *CSC ATC Aptitude Screening Battery Scores.* As pointed out earlier, the Regions forwarded Composite Scores on the operationally administered CSC Screening Battery for 59 of the 83 females and for 512 of the 798 GS–7 level males who entered Academy ATCS training during 8 May 1969 through 31 July 1969. Part scores (i.e., measures on the five different CSC Test Booklets) were also forwarded for 46 of the 59 women and 355 of the 512 men for whom Composite Scores were available. Moreover, the design of the larger research project, of which this study is but a part, specified that several incoming Academy groups be experimentally administered one to three parts of the CSC Battery and that a few classes also be experimentally assessed with the entire CSC Battery. Fourteen of the 83 females involved in the present study were experimentally administered all five CSC instruments. The complete CSC Battery was also administered, on an experimental basis, to 599 GS–7 level male trainees of various classes, including some, but not all, of the classes used in establishing our basic sample of 798 males.

Figure 7 presents data reflecting the mean performance of the females relative to the males on both the operationally and experimentally administered CSC instruments. It should be emphasized that although the data presented in Figure 7 pertain to overlapping samples, many of the experimentally examined males were in Academy classes other than those which yielded the sample of 798. (In other words, the findings depicted in Figure 7 are not based on "test-retest" data only.) The cases comprising the male samples, like those of the female samples, are also quite variable in number. In most instances, however, both the female and male samples are of sufficient size to permit a reliable comparison of their performance on the different parts of the CSC Battery.

An examination of Figure 7 will reveal that the women performed almost as well or better than the men on every element (i.e., test booklet) of the CSC Battery. Composite Scores forwarded for 59 females on the operationally administered battery averaged 250.3 whereas those provided for 512 males averaged 246.7; the difference was not statistically significant. Only 14 females and 599 males were experimentally administered the complete CSC Battery, but the mean difference of 7.7 points between the Composite Scores again favored the women. Differences between the mean scores of the females and males were quite small on both the operationally and experimentally administered tests referred to as CSC–51 Spatial Relations, CSC–135 Following Oral Directions, and CSC–540 Air Traffic Problems.



CSC-ATC Battery		Oper.	Exp.	Oper.	Exp.	Oper.	Exp.	Oper.	Exp.	Oper.	Exp.	Oper.	Exp.
		CSC-24 Number Facil.		CSC-51 Spatial Rel.		CSC-135 Fol. Oral Dir.		CSC-157 Abst.R. & L.S.		CSC-540 Air Traf. Prbs.		CSC Total Composite	
Female Trainees	N:	46	30	46	22	46	47	46	25	46	63	59	14
	Mean:	49.1	42.5	30.9	30.0	28.5	28.5	36.8	34.5	40.1	36.5	250.3	239.8
	S.D.:	6.6	7.5	4.0	4.4	5.1	4.6	5.5	6.3	8.9	10.4	20.8	31.5
Male Trainees	N:	355	340	355	273	355	318	355	255	355	423	512	599
	Mean:	42.6	41.6	31.5	30.1	29.5	28.0	33.6	31.5	39.5	37.6	246.7	232.1
	S.D.:	7.8	7.6	3.5	3.4	4.6	4.7	6.3	6.9	9.8	11.3	23.1	29.6
Mean Diff.:		6.5*	0.9	0.6	0.1	1.0	0.5	3.2*	3.0*	0.6	1.1	4.4	7.7

FIGURE 7. Relative perormance of female and male ATCS Trainees on the five tests of the CSC-ATC Aptitude Battery when administered operationally for screening purposes and when administered experimentally.

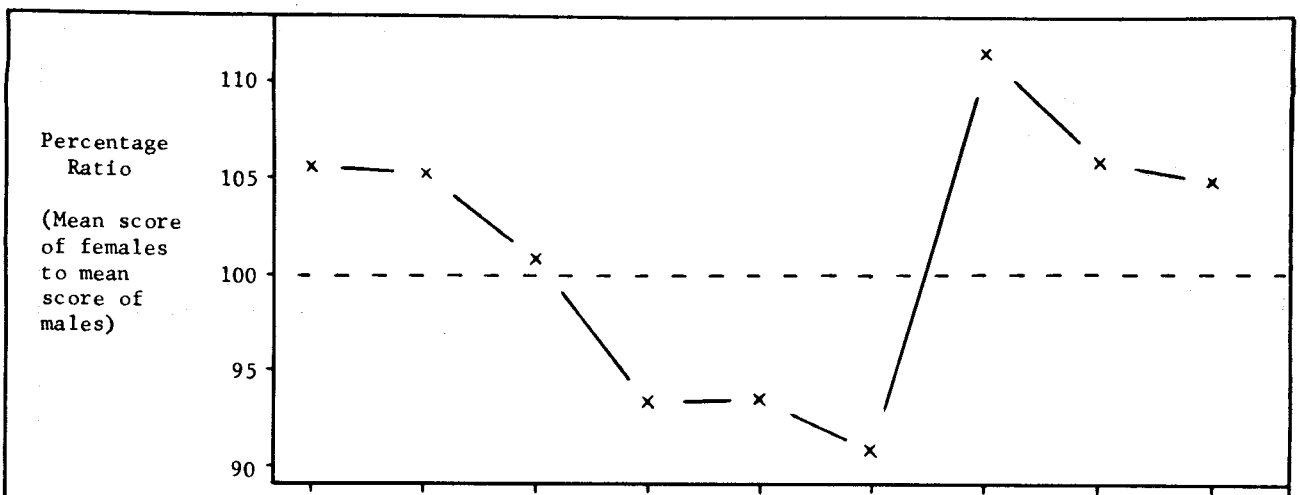
*Difference is significant at less than the .05 level.

The most notable difference, which was statistically significant ($p<.01$), pertained to the operationally administered CSC–24 Number Facility Booklet; the mean score of the women was 49.1, while that of the men was 42.6.

In order to plot the performance of the females on each of the instruments *relative* to that of the males, a percentage ratio was obtained. For example, the mean score of 49.1 for the females on CSC–24 Number Facility was divided by the 42.6 obtained from the male sample, resulting in a quotient of 115 after omission of the decimal point. Inasmuch as 100 represented the average score of the males, the 115 denoted that the females scored 15 per cent higher than the males on the operationally administered CSC–24 Booklet. Surprisingly, there was little difference between the mean scores of the females and males who were experimentally administered the CSC–24 Booklet at the time of entry into Academy training.

The women also tended to score appreciably higher than the men on the CSC–157 Booklet—a two-part test involving non-verbal abstract reasoning. The mean difference with respect to the operationally derived scores was 3.2 score points and 3.0 score points with respect to performance in the experimental situation; these differences were statistically significant at the .01 and the .05 levels, respectively. In each instance, the mean score of the females was almost 10 per cent higher than that of the males.

C. *Other Experimentally Administered Tests.* Figures 8 and 9 follow the same format as Figure 7 but present data relating to a number of other tests which were administered on an experimental basis to portions of the female group and to sizable samples of male GS–7 trainees. All but three of the tests for which results are presented are commercially published and copyrighted instruments; the Directional Headings Test and the Symbol-to-Digit decoding test represent CAMI development efforts; "Locating Data" represents a CAMI revision of a test previously developed



Tests Experimentally Administered		Press Test Pt. I	Press Test Pt. II	Press Test Pt. III	Direct. Heading Pt. I	Direct. Heading Pt. II	Direct. Heading Pt. III	CAMI Symbol -Digit	WAIS Digit-Symbol	A. I. R. Locating Data
Female Trainees	N:	12	12	12	26	26	16	32	25	54
	Mean:	84.2	82.8	65.5	32.6	32.1	36.8	41.2	64.7	29.7
	S.D.:	8.0	10.4	9.0	11.7	14.6	12.9	5.6	10.6	6.1
Male Trainees	N:	251	251	231	344	366	326	385	302	359
	Mean:	79.7	78.6	64.9	34.9	34.3	40.5	37.0	61.1	28.3
	S.D.:	14.6	13.0	12.1	8.8	11.3	11.2	6.6	9.6	5.2
Mean Diff.:		4.5	4.2	0.6	2.3	2.2	3.7	4.2*	3.6	1.4

FIGURE 8. Relative performance of female and male ATCS Trainees on the experimentally administered Press, CAMI Directional Headings, CAMI Symbol-to-Digit, WAIS Digit-to-Symbol, and Locating Data tests.

* Difference is significant at less than the .05 level.

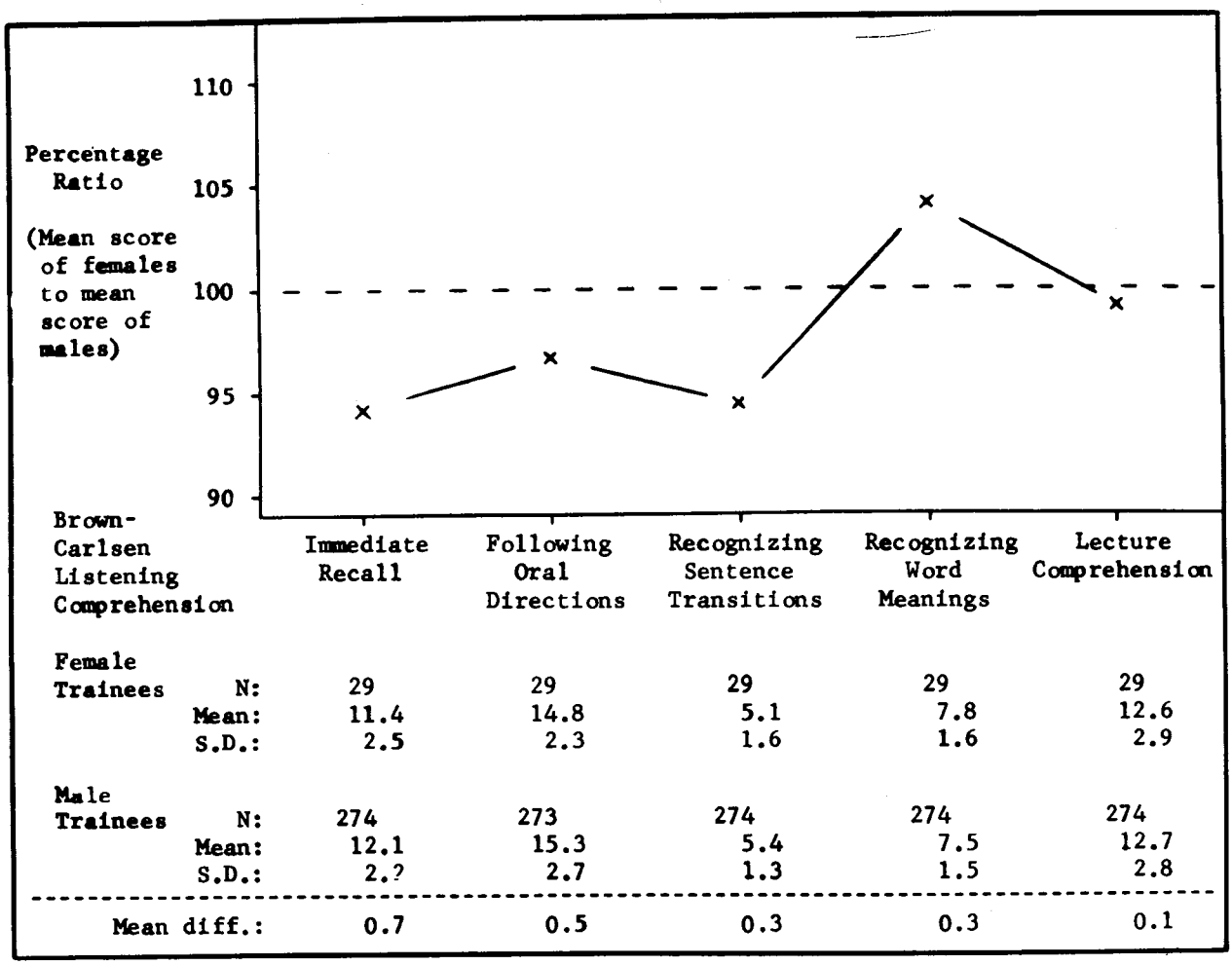
for the FAA by the American Institute of Research.

Looking first at Figure 8, it should be noted that the performance means of the females were *below* those of the males for only three of the nine variables. The three pertain to the CAMI Directional Headings Test (or DHT); on Part I and Part II, the women scored about 7 per cent lower than the men and, on Part III, about 10 per cent lower than the men. Although none of the mean differences proved statistically significant, the entire study revealed no other test, subtest, or part of a test with which the women experienced as much difficulty, relative to the men, as on the DHT.

The mean performance of the women was *higher* than that of the men on the three parts of the Press Test and on the Locating Data ,WAIS Digit-to-Symbol, and CAMI Symbol-to-Digit tests. In only one case, however, was their average score significantly above that of the males; on the CAMI Symbol-to-Digit Test, the mean sex difference of 4.2 score points was statistically significant at the .01 level.

The data presented in Figure 9 pertain to the five parts, or subtests, of the Brown-Carlsen Listening Comprehension Test (BC-LCT). The test is similar in many respects to CSC–135 Following Oral Directions (for which results were shown in Figure 7) and, like the latter, revealed no statistically significant differences between the sex groups although the performance means of the females were below those of the males on four of the five BC-LCT subtests.

A summary analysis of the data presented in Figures 7, 8, and 9 was accomplished by ranking



Brown-Carlsen Listening Comprehension		Immediate Recall	Following Oral Directions	Recognizing Sentence Transitions	Recognizing Word Meanings	Lecture Comprehension
Female Trainees	N:	29	29	29	29	29
	Mean:	11.4	14.8	5.1	7.8	12.6
	S.D.:	2.5	2.3	1.6	1.6	2.9
Male Trainees	N:	274	273	274	274	274
	Mean:	12.1	15.3	5.4	7.5	12.7
	S.D.:	2.?	2.7	1.3	1.5	2.8
Mean diff.:		0.7	0.5	0.3	0.3	0.1

FIGURE 9. Relative performance of female and male ATCS Trainees on the five subtests of the experimentally administered Brown-Carlsen Listening Comprehension test.

the test performance variables in terms of the percentage ratios, as indicated in Section B of this Phase III discussion. Although the resulting array is not presented in this report, the percentage ratios for the 19 experimentally administered tests or subtests, ranging from 90.9 (for Part III of Directional Headings) to 111.4 (for CSC–157 Abstract Reasoning and Letter Sequence), averaged 100.6, and 10 of the 19 were larger than 100.0. When the operationally derived data for the five CSC Booklets were included, a similar array revealed that 13 of the 24 percentage ratios exceeded 100.0. The average for the ratio values for the entire 24 was 101.3, indicating that the average performance of the females slightly exceeded that of the males.

In the latter array, the operationally administered CSC–24 Number Facility Test, with a percentage ratio of 115.3, ranked first. The next highest value was 111.4, for the CAMI Symbol-to-Digit Test, followed by identical values of 109.5 for the operationally and experimentally administered CSC–157 Abstract Reasoning and Letter Sequence Booklet. The WAIS Digit-to-Symbol subtest ranked fifth with 105.9 while slightly lower values resulted in Parts I and II of the Press Test being ranked sixth and seventh, respectively. Other percentage ratios above 100.0 pertained to the BC-LCT Recognizing Word Meanings, the experimentally administered CSC–24 Number Facility and CSC–135 Following Oral Directions tests, the operationally administered CSC–540 Air Traffic Problems Booklet and Part III of the Press Test. Percentage ratios which ranged from 99.2 down to 96.6 pertained to the operationally and experimentally administered CSC–51 Spatial Relations Booklet, Lecture Comprehension of the BC-LCT, the experimentally

administered CSC–540 Air Traffic Problems Test, the BC-LCT Following Oral Directions, and the operationally administered CSC–135 Following Oral Directions Booklet. Percentage ratios of 94.4 and 94.2, for the Brown-Carlsen subtests of Recognizing Sentence Transitions and Immediate Recall, ranked 20th and 21st. The women generally experienced increasingly greater difficulty than the men on Parts II, I, and III of the Directional Headings Test; DHT Part III, which involved aural distraction, yielded a percentage ratio of 90.9—lower than for any other aptitude test variable. As pointed out earlier, however, there was no test or subtest on which their performance mean was significantly *lower* than that of the males while there were four instances where their mean scores were significantly *higher* than obtained for the males. As may be recalled, the latter pertained to the operationally administered CSC–24 Number Facility Booklet, the experimentally administered CAMI Symbol-to-Digit (Decoding) Test, and both the operationally and experimentally administered CSC–157 Booklet (which contained the non-verbal Abstract Reasoning and Letter Sequence Tests).

D. *Aptitude Differences Relative to Those of General Population Samples.* The findings regarding the relative aptitude levels of the female and male ATCS trainees are similar in some respects to those cited by Anastasi,[1] Droege,[7] and Maccoby[9] in their summaries of research on the aptitudes and cognitive abilities of men and women representative of a general population. They indicate that women generally perform significantly better than men on tests involving: rapid perception of details and frequent shifts of attention, coding or decoding abilities, reading comprehension, and grammar, vocabulary, and other verbal functions. In the present study, the scores of the females averaged higher (though not significantly higher) than the males on the two tests which most notably involved rapid perception of details: the Locating Data Test and the Press Test. The female ATCS trainees also tended to perform better than the males on the WAIS Digit-to-Symbol Coding subtest and on CAMI's Symbol-to-Digit (Decoding) Test. Findings with regard to verbal functioning were inconsistent; the performance of the women was slightly above that of the men on BC-LCT Recognizing Word Meanings and slightly below that of the males on BC-LCT Recognizing Sentence Transitions.

Anastasi,[1] like Droege,[7] indicates that women are also apt to perform: slightly *better* than men on tests pertaining to numerical ability, verbal abstract reasoning, and word memory; slightly *less well* than men on tests involving verbal analogies, non-verbal abstract reasoning, and mathematical or quantitative reasoning; and that they are apt to experience considerably greater difficulty than men on tests relating to spatial orientation, mechanics, science, physics, and the like. In the current study, the groups of female examinees scored significantly higher, rather than slightly higher, than the males on CSC–24 Number Facility and slightly lower than males, instead of slightly higher, on BC-LCT Immediate Recall (which pertains to word memory). Unlike women in the general population who tend to perform less well on tests of non-verbal abstract reasoning, the females examined in this study scored significantly higher than the males on CSC Booklet 157.

Moreover, the females performed at a comparable level with the males on CSC Booklet 51 Spatial Relations and the mean score of the nine women assessed with the Dailey Spatial Visualization Test was actually a few points higher than that of the men (see Table 6). Very few of the females were examined with other types of tests on which men traditionally exhibit relatively superior performance. In every instance, however, the results followed the expected trend; as shown in Table 6, the mean scores of the female trainees were substantially below those of the males on TST Mechanics, VETB Mechanical Reasoning, TST Electricity, and TST Electronics.

ADDENDUM

Attritions Between April and December 1971. Subsequent to the completion of this report, records updated as of December 1971 revealed that an additional 10 of the 66 female Academy graduates terminated their service during the intervening seven months (i.e., after April 1971) whereas only 21 additional males were attrited during the same period. In other words, as of December 1971, the attrition rate for the 66 females who had survived Academy training was 48.5 per cent while that of the 613 male graduates was only 22.5 per cent.

IV. Summary and Concluions.

This study compares age, education, pre-FAA experience, aptitudes, training-course performance measures, and post-Academy attrition rates of the 83 women who entered basic air traffic control (ATC) training at the FAA Academy during November 1968 through March 1970 with those of various samples of the 3,760 males who entered training during the same period. The study revealed no significant differences between the means of the female and male trainees with respect to age and educational level. When samples of the 83 females were compared with groups of male trainees in terms of performance on 36 different aptitude tests, only four mean differences, all of which favored the females, proved statistically significant. Only 45.8 per cent of the 83 women had pre-FAA ATC-related experience, while such experience was possessed by 63.9 per cent of a sample of 798 males; the difference was significant at the .01 level. The means of the training course grade averages of the two groups differed by only three-tenths of one point and there was no significant difference between the Academy attrition rate of 20.5 per cent for the females and 23.2 per cent for the 798 males. However, the groups differed markedly with respect to post-Academy attrition rates. It was determined that 33.3 per cent of the 66 females who completed Academy basic training were no longer in the air traffic management system as of April 1971 whereas only 19.1 per cent of the 613 males (within the sample of 798) who graduated from the Academy were subsequently attrited.

This study, like others of recent years, has also demonstrated that the FAA selects the vast majority of its ATCS trainees from among candidates who are far superior to the general population in terms of intellectual or cognitive abilities.

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