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Validity of the Air Traffic Control Specialist Nonradar Screen as a Predictor of Performance in Radar-based Air Traffic Control Training

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16. Abstract

Between January1986 and March 1992, the Federal Aviation Administration's 42-day Nonradar Screen was used to identify Air Traffic Control Specialist (ATCS) candidates with the highest potential to succeed in the rigorous ATCS field training program. The central question addressed in this study was whether or not the Nonradar Screen was a valid employee selection procedure in view of the prevalence of radar in today's air traffic control system. To answer that question, we investigated the Nonradar Screen's criterion-related validity as a predictor of subsequent performance in radar-based air traffic control training. We hypothesized that the Nonradar Screen would add incremental validity over aptitude test scores in predicting performance in radar-based air traffic control (ATC) training conducted at the FAA Academy 1 to 2 years after entry into the occupation. Student aptitude test scores and Nonradar Screen final composite scores were regressed on final composite scores earned in radar-based ATC training. Results showed that Nonradar Screen composite scores had incremental validity over the written ATCS aptitude test for predicting radar-based training scores in both en route ($\Delta R^2 = .08$, $F(2,438) = 36.52$, $p \leq .001$) and terminal ($R^2 = .10$, $F(2,658) = 77.66$, $p \leq .001$) radar training without correcting for range restriction due to explicit selection on the Nonradar Screen final composite score. After corrections for restriction in range, Nonradar Screen scores accounted for an additional 20% of variance in en route ($\Delta R^2 = .20$, $F = 146.84$, $p \leq .001$) and an additional 16% of variance in terminal ($R2 = .16$, $F = 178.58$, $p \leq .001$) radar training scores. These results indicated that the Nonradar Screen was a valid predictor of performance in radar-based ATC training. Similarities in nonradar and radar procedures and techniques are offerred as possible explanations for the finding of criterion-related validity for the ATCS Nonradar Screen.

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Validity of the Air Traffic Control Specialist (ATCS) Nonradar Screen as a Predictor of Performance in Radar-based Air Traffic Control Training

The FAA air traffic control specialist (ATCS) selection system, from October 1985 through January 1992, consisted of two stages. The first stage was the written Office of Personnel Management (OPM) air traffic control selection test battery. Less than 10% of over 200,000 applicants that completed the first stage written examination were chosen to progress to the second stage, the 42-day Nonradar Screen. During this period, of the 14,392 persons that entered the Nonradar Screen, 56.6% were successful and assigned to field facilities for up to 5 years of developmental training. Some 80% of these trainee controllers, termed "developmentals," were assigned to training in terminal or en route facilities equipped with radar. Terminal facilities provide air traffic control (ATC) services at and around airports, while en route facilities generally provide ATC services between airports. In view of the high placement rate into radar-equipped facilities, concern was raised about the validity of the Nonradar Screen as a predictor of performance in the radar-based environment of today's air traffic control system (Aerospace Sciences, Inc., 1991).

Della Rocco, Manning, and Wing (1990) had also questioned the validity of the Nonradar Screen as a predictor of success in radar-based air traffic control. They compared the content of the Nonradar Screen to tasks performed by an en route radar controller and concluded that many of the behaviors assessed in the Nonradar Screen were similar to those required in the radar environment (p. 19). No statistical analyses of the relationship of Nonradar Screen score to radar-oriented criteria were presented to buttress the argument for content validity. However, Della Rocco, et al. (1990) did show that the Screen predicted status in field training for persons assigned to en route air traffic facilities ($r = -.24$, $N = 406$, $p \leq .01$). Field training status in that study was coded: 1 = ***Full Performance Level***; 2 = ***In Training in Original Option***; 3 = ***Switched Options***; and 4 = ***Failed.*** The estimated population validity coeffficient for the Screen after correcting for restriction in range was -.44.

The purpose of this research was to build on that previous study by empirically assessing the criterion-related validity of the Nonradar Screen for the prediction of performance in radar-based ATC training.. Radar training was used in this study as a surrogate criterion for actual radar ATC job performance because adequate on-the-job measures were not available. We hypothesized that the final composite score in the Nonradar Screen would show significant incremental validity over the OPM aptitude test score in the prediction of radar-based ATC training performance.

Method

Sample

The sample used in this study was comprised of 1,639 first-time competitive entrants to the Screen who had also attended the en route or terminal radar training programs. The sample entered the Nonradar Screen during the years 1987 to 1990, and attended the radar course at some time between 1988 and 1991. Table 1 presents overall sample demographic characteristics, as compared with the population of all comparable first-time, competitive Nonradar Screen entrants entering the system since October 1985. Fewer minorities and women were represented in this sample than were in the population of Nonradar Screen entrants. Controllers assigned to terminal facilities were also over-represented in comparison to historical placements due to differences in program enrollment policies.

Measures

Aptitude score. The written aptitude test was administered by the U.S. Office of Personnel Management (OPM) as the first stage in the ATCS selection system. The general development, psychometric characteristics, and validity of this test battery have been extensively described (Della Rocco, Manning, & Wing, 1990; Manning, Della Rocco, & Bryant, 1989; Rock,

Table 1
Sample demographic characteristics

Characteristic	Category	Population (*N* = 14,392)		Sample (*N* = 1,639)	
Age	*Mean*	26.00		25.42	
	SD	2.99		2.76	
Sex	*Male*	79.6%	(11,460)	86.6%	(1,420)
	Female	20.4%	(2,932)	13.4%	(219)
Race	*Native American*	0.6%	(91)	0.5%	(8)
	Asian	1.4%	(195)	0.4%	(7)
	African American	5.7%	(819)	3.2%	(52)
	Hispanic Non-white	3.6%	(525)	1.9%	(31)
	White Non-hispanic	85.9%	(12,366)	91.3%	(1,496)
	Unknown	2.8%	(396)	2.7%	(44)
Assigned Option	*En Route*	33.3%	(4,786)	39.7%	(651)
	Terminal	23.3%	(3,354)	60.3%	(988)
	Not Applicable[1]	43.4%	(6,252)		

NOTES: [1]Assigned option not applicable for persons who failed or withdrew from the Nonradar Screen

Dailey, Ozur, Boone, & Pickrel, 1982; Sells, Dailey, & Pickrel, 1984). The written civil service ATCS aptitude battery was composed of: (a) the *Multiplex Controller Aptitude Test*; (b) a test of *Abstract Reasoning*; and (c) an *Occupational Knowledge Test*. Results from the test battery were combined with any veteran's preference points to yield a final civil service rating (RATING) for competitive entrants. This rating was used to rank-order competitive ATCS job applicants within statutory guidelines, such that hiring was done on the basis of merit (Aul, 1991). A candidate with a qualifying aptitude score was also required to undergo medical and security evaluations and complete an interview before being hired. The successful applicant was then hired by the FAA and enrolled in the Nonradar Screen. This overall civil service RATING was used as the measure of aptitude for the ATCS occupation in this study. Mean aptitude scores for the sample of Nonradar Screen students who attended radar training are compared with the population of Nonradar Screen entrants for which scores were available in Table 2. Mean RATING differences between the samples and population were not statistically significant.

ATCS Screen score. Persons competitively hired into the ATCS occupation (GS-2152; U.S. Department of Labor (1977) *Dictionary of Occupational Titles* job code 193.162-018) by these civil service procedures reported to the FAA Academy and were enrolled in the Nonradar Screen. The Nonradar Screen was originally established in response to recommendations made by the U.S. Congressional House Committee on Government Operations (U.S. Congress, 1976) to reduce field training attrition rates. The Nonradar Screen was based upon a miniaturized training-testing-evaluation personnel selection model (Siegel, 1978, 1983; Siegel & Bergman, 1975) in which individuals with no prior knowledge of the occupation were trained and then assessed for their potential to succeed in a job.

Table 2
Descriptive statistics for aptitude, Screen, and Academy RTF scores

	Population			En Route ($N = 651$)			Terminal ($N = 988$)			Combined Options ($N = 1,639$)		
Measure	*Mean*	*SD*	*N*	*Mean*	*SD*	*N*	*Mean*	*SD*	*N*	*Mean*	*SD*	*N*
RATING	92.25	4.66	10,918	92.37	4.47	549	92.34	4.65	827	92.34	4.58	1,376
SCREEN	71.66	11.35	10,014	79.88	5.91	651	77.78	6.78	988	78.61	6.53	1,639
ENRT_RAD	84.32	7.90	3,320	84.14	5.27	533						
TERM_RAD	82.38	12.85	3,081				80.32	6.44	805			

Overall, 56.6% of all entrants successfully completed the Nonradar Screen over the period of January 1986 to March 1992.

Thirteen assessments of performance, including classroom tests, observations of performance in laboratory simulations of non-radar air traffic control, and a final written examination, were made during the Nonradar Screen (Della Rocco, Manning, & Wing, 1990). The final summed composite score (SCREEN) was weighted 20% for academics, 60% for laboratory simulations, and 20% for the final examination. A minimum SCREEN score of 70 was required to pass the Nonradar Screen. This final composite score was the predictor of interest in this study. SCREEN scores for this sample are compared in Table 2 with the population of first-time competitive Nonradar Screen entrants. Mean SCREEN scores for the terminal and en route samples were higher than those of the population, due to explicit selection of the sample on SCREEN.

Radar score. Those persons who successfully completed the Nonradar Screen entered into long-term occupational technical training as developmentals in either en route or terminal facilities. Both en route and terminal controllers ensure the separation of aircraft by using information about the speed, direction, and altitude of aircraft to (a) formulate clearances and (b) communicate those clearances to pilots. Clearances are sets of instructions designed to ensure the safe, orderly, and expeditious flow of air traffic.

After successfully completing the Screen, ATCSs generally reported to their specific facility assignments, and received training on the ATC procedures specific to their assigned airspace. During the period examined in this study, most controllers assigned to facilities utilizing radar procedures returned to the FAA Academy for initial radar training at the FAA Academy Radar Training Facility (RTF). Radar training courses were conducted separately for each type of facility using the high-fidelity simulation capabilities of the Academy RTF.

The Academy RTF terminal ("Terminal RTF") and en route ("En Route RTF") courses instructed the developmental controller in basic radar techniques in the safety of a simulated airspace before the controller applied those skills in a live traffic environment during subsequent phases of on-the-job training. Instruction covered topics such as, principles of radar, radar identification procedures, radar separation procedures, vectoring, speed control, and radar handoffs (Boone, van Buskirk, & Steen, 1980; Federal Aviation Administration, 1991). Topics specific to a facility type were also covered in the respective courses, such as departure and arrival procedures in Terminal RTF. Didactic classroom instruction was provided to students, and written, multiple-choice examinations were administered at the end of academic instruction. Since 1986, those written examinations comprised 30% of the final radar composite score in each option. Students then applied that knowledge in a series of increasingly complex radar control problems. The last five control problems were graded, and comprised 70% of the total composite grade in each radar course. Mean final radar composite scores (ENRT_RAD for en route, TERM_RAD for terminal) for this sample are compared with their respective population means in Table 2.

Procedure

Multiple regression was used to test the hypothesis that performance in the Nonadar Screen (SCREEN) added incremental validity over aptitude (RATING) in the prediction of performance in radar training (ENRT_RAD or TERM_RAD). Separate analyses were conducted for the en route and terminal courses in light of apparent differences between control techniques, procedures, and rules in the two ATC environments. The analyses were conducted using both raw data and a correlation matrix corrected for explicit and incidental restriction in range due to selection on SCREEN as required by the *Uniform Guidelines on Employee Selection Procedures* (Equal Employment Opportunity Commission, 1978). Specifically, correlations between RATING and SCREEN for each group were corrected for range restriction due to prior selection on SCREEN. Correlations between RATING and radar composite scores for each group were corrected for incidental restriction in range due to the selection of the sample on SCREEN. Finally, the correlations between SCREEN and ENRT_RAD and TERM_RAD were corrected for explicit restriction in range due to selection on SCREEN, using formulae presented by Ghiselli, Campbell, and Zedeck (1981, p. 299). Corrected matrices for en route and terminal trainees were submitted separately for regression analysis. In the regression analyses, RATING was first entered into the prediction equation to assess the amount of variance in radar composite scores accounted for by aptitude. SCREEN was then regressed on radar performance by using a stepwise entry to assess the incremental validity of SCREEN for each ATC environment.

Results

En Route

The zero-order correlations between RATING, SCREEN, and ENRT_RAD are presented in Table 3. These correlations are likely to be underestimated, because of the high degree of restriction in range due to explicit, successive selections on both RATING and SCREEN. Performance in the Nonradar Screen was significantly correlated with performance in en route radar training ($r = .28$, $N = 533$, $p \leq .001$). Correcting for explicit restriction in range increased the RATING - SCREEN and SCREEN - ENRT_RAD correlations to .37 and .50 respectively (as shown in parentheses) in Table 3. The correlation between RATING and SCREEN increased from .20 ($N = 549$, $p \leq .001$) to .22 after correction for incidental restriction in range. This was consistent with other studies examining the validity of the written aptitude examination (Manning, Della Rocco, & Bryant, 1989; Manning, Kegg, & Collins, 1989).

The results of the en route regression analysis are presented in Table 4. RATING was forced into the equation in the first step ($R = .17$, $F(1{,}439) = 13.19$, $p \leq .001$), and accounted for about 3% of variance in ENRT_RAD. SCREEN was then regressed on ENRT_RAD in the second block, using a stepwise procedure to control variable entry. SCREEN accounted for an additional 8% of variance in ENRT_RAD ($\Delta R^2 = .08$, $F = 36.52$, $p \leq .001$) without correction for restriction in range. After correcting the SCREEN - ENRT_RAD correlation for restriction in range, SCREEN accounted for an additional 20% of variance in radar training performance ($\Delta R^2 = .20$, $F = 146.84$, $p \leq .001$). The corrected partial correlation between SCREEN and radar performance for en route developmentals was .48 ($t(1{,}438) = 12.12$, $p \leq .001$).

Terminal

The zero-order correlations between RATING, SCREEN, and TERM_RAD are presented in Table 5. The uncorrected correlation of .26 ($N = 827$, $p \leq .001$) between RATING and SCREEN was consistent with other studies examining the validity of the written aptitude examination (Manning, Kegg, & Collins, 1989), as was the correlation of .19 ($N = 661$) between RATING and TERM_RAD. These correlations were

Table 3

En Route descriptive statistics, zero-order correlations, and correlations corrected for range restriction

Measure	*Mean*	*SD*	N	RATING	SCREEN
RATING	92.37	4.47	549		
SCREEN	79.88	5.91	651	.20*** (.37)	
ENRT_RAD	84.14	5.27	533	.17*** (.22)	.28*** (.50)

NOTES: Correlations corrected for range restrictions shown in parentheses. *** $p \leq .001$

Table 4
Incremental validity of Nonradar Screen score in predicting en route radar training scores

Step	Variable	β	R	R^2	Adj-R^2	ΔR^2	ΔF	$F(df)$
			Before correction for range restriction					
1	RATING	.17	.17	.03	.03			13.19*** (1,439)
2	RATING	.13						
	SCREEN	.26	.32	.10	.10	.08	36.52***	25.39*** (2,438)
			After correction for range restriction					
1	RATING	.22	.22	.05	.048			28.81*** (1,438
2	RATING	.05						
	SCREEN	.48	.501	.25	.25	.20	146.84***	91.67*** (2,437)

NOTES: Shrunken R^2 (Adj-R^2) reported as more accurate estimates of true incremental validity, given sample size and number of predictors. The statistical tests associated with the analyses after corrections for range restriction should be interpreted *very* cautiously.

***$p \leq .001$

Table 5

Terminal zero-order raw and correlations corrected for range restriction

RATING	**92.34**	**4.65**	**827**		
SCREEN	**77.78**	**6.78**	**988**	**.26*** (.41)**	
TERM_RAD	**80.32**	**6.44**	**988**	**.19*** (.32)**	**.31*** (.50)**
Measure	***Mean***	***SD***	**N**	**RATING**	**SCREEN**

***NOTES*: Correlations corrected for range restrictions shown in parentheses** *** $p \leq .001$

likely to be underestimated, because of the high degree of restriction in range due to explicit, successive selections on both RATING and SCREEN. SCREEN was significantly correlated with performance in terminal radar training ($r = .31$, $N = 805$, $p \leq .001$). Correcting for explicit restriction in range due to selection on SCREEN increased the RATING - SCREEN and SCREEN - TERM_RAD correlations to .41 and .50 respectively (as shown in parentheses) in Table 5. The RATING - TERM_RAD correlation increased to .32 after correction for incidental restriction range due to selection of the sample on SCREEN.

The results of the terminal regression analysis are presented in Table 6. RATING was forced into the equation in the first step ($R = .19$, $F(1,659) = 23.66$, $p \leq .001$), and accounted for about 3% of variance in TERM_RAD. SCREEN was then regressed on TERM_RAD in the second block, using a stepwise procedure to control variable entry. SCREEN scores accounted for an additional 10% of variance in terminal radar training performance ($\Delta R^2 = .10$, $F = 77.66$, $p \leq .001$). After correcting the SCREEN - TERM_RAD correlation, SCREEN scores accounted for an additional 16% of variance in TERM_RAD ($\Delta R^2 = .16$, $F = 178.58$, $p \leq .001$). The corrected partial correlation between SCREEN and radar performance for developmentals assigned to terminal facilities was .44 ($t(1,659) = 13.63$, $p \leq .001$).

Discussion

The results suggest that, for developmentals assigned to en route facilities, the Nonradar Screen score added significantly to the prediction of radar training performance, over and above the contribution of the aptitude score. The percentage of variance accounted for by both predictors in this study (10% uncorrected) is consistent with that found by Manning (8% uncorrected; 1991) when predicting status in facility-specific en route field training. However, in Manning's (1991) study, the aptitude score contributed about as much to the prediction of field training performance as did the Nonradar Screen score after correcting for range restriction. Manning reported a partial correlation between aptitude and en route field status of .29 and a partial correlation of .39 between Nonradar Screen score and field status. In this study, the Nonradar Screen score had the higher partial correlation with performance in radar training. The results obtained in the present study also suggested that the Nonradar Screen was a reasonably valid predictor of terminal radar training performance. Moreover, the correlation between Nonradar Screen and terminal radar training performance (.31 uncorrected) in this study was consistent with the correlation between the Nonradar Screen score and instructor's assessment of developmental performance in the facility radar qualification

Table 6
Incremental validity of Nonradar Screen score in predicting terminal radar training scores

Step	Variable	β	*R*	R^2	Adj-R^2	ΔR^2	ΔF	*F*(*df*)
			Before correction for range restriction					
1	RATING	.19	.19	.04	.03			23.66*** (1,659)
2	RATING	.12						
	SCREEN	.33	.37	.14	.13	.102	77.66***	52.03*** (2,658)
			After correction for range restriction					
1	RATING	.32	.32	.11	.10			96.69*** (1,659)
2	RATING	.14						
	SCREEN	.44	.51	.26	.26	.16	178.58***	148.04*** (2,658)

NOTES: Shrunken R^2 (Adj-R^2) reported as more accurate estimates of true incremental validity, given sample size and number of predictors. The statistical tests associated with the analyses after corrections for range restriction should be interpreted *very* cautiously.

***$p \leq .001$

phase of field training (.30, uncorrected) reported by Manning, Della Rocco, and Bryant (1989). We concluded that performance on nonradar air traffic control tasks was a valid indicator of potential to perform radar-based air traffic control tasks.

However, there may be alternative explanations for the significant relationship between the Nonradar Screen score and radar training performance. First, procedures for grading of classroom examinations and laboratory simulation problems in the Nonradar Screen and the En Route and Terminal Radar courses were very similar. Both courses contained written tests comprised of multiple choice items. In the laboratory problems administered during each course, instructors observed student performance over a 30-minute time period, recorded specific technical errors made by the student, and provided feedback after the problem was completed. Errors included the failure to maintain sufficient separation between aircraft, failure to use appropriate procedures, failure to coordinate appropriately with other controllers, and failure to use proper phraseology in the Nonradar Screen and both radar training courses. Scores on the laboratory problems in all courses were based upon a weighted composite of the errors committed, where the more serious errors (e.g., separation) received higher weights than did the less serious errors. Similarity in the content of the materials and the grading of the laboratory problems may have resulted in shared method variance that might account for a portion of the correlation in performance between the nonradar and radar courses.

On the other hand, many of the activities involved in controlling air traffic using en route radar, terminal radar, or en route nonradar procedures are similar. Both en route and terminal radar controllers perform the primary activities of monitoring aircraft positions, resolving aircraft conflicts, managing air traffic sequences, planning flights, assessing the impact of weather, and managing position resources (Alexander, Ammerman, Fairhurst, Hostetler, & Jones, 1989, 1990). However, within each global activity, subactivities differ for en route and terminal radar controllers. In spite of some equipment and procedural differences between the two options, performance in each option's training program was predicted about equally well by the combination of nonradar and aptitude scores.

The results of this study provide evidence of the validity of the Nonradar Screen in predicting radar training performance (over and above the prediction of the first-stage OPM selection battery). This provides empirical support for the logical arguments for a relationship between nonradar and radar ATC activities. These results also indicate that nonradar simulations cannot be dismissed as predictors of radar-based ATC on the basis of "face validity." Rather, additional research is required to elucidate the cognitive constructs underlying this empirical relationship between nonradar and radar air traffic control performance as a part of the development of new ATCS selection tests.

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