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ESTIMATING SKILL DEGRADATION FOR AVIATION ANTISUBMARINE WARFARE OPERATORS (AWs): LOSS OF SKILL AND KNOWLEDGE FOLLOWING TRAINING

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ESTIMATING SKILL DEGRADATION FOR AVIATION ANTISUBMARINE WARFARE OPERATORS (AWs): LOSS OF SKILL AND KNOWLEDGE FOLLOWING TRAINING

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Subjects, 20 AWs in the S-3A training pipeline who attended a basic acoustic analysis course and a follow-on operator course, were tested to determine if they retained the skills and knowledge required for satisfactory performance of acoustic analysis and classification over the 25-day nonutilization period between the two courses. The original learning measure was the basic course final examination, comprised of (1) a multiple-choice knowledge exam consisting of both factual and computational items, and (2) a

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performance test that examined student performance of acoustic analysis and classification procedures on static linear lofargrams. The retention measure, administered approximately 1 month later, consisted of alternate forms of the original measure. Results showed that students performed better on the original measure than on the retention tests for most of the variables analyzed. Significant differences were found for all scores on the knowledge test (overall, the factual test items, and the computational test items) and for performance for the analysis variables on the performance test. No significant differences were found for the classification variable. It was concluded that, over the 25-day nonutilization period, the skills and knowledge of students in the S-3A acoustic analyst training pipeline degraded significantly.

FOREWORD

This research and development was performed in response to recognized Navy needs for an investigation of the effects of initial training and job conditions on skill retention under subproject RF63-522-001 (Computer-aided and Classroom Training), work unit 03.07 (Skill and Knowledge Retention). This issue was initially addressed in a paper prepared in 1976 in response to a request from the Chief of Naval Operations (OP-96), citing the concern that training and job conditions might not be conducive to the maintenance of competent performance. The objectives of the subproject are to (1) derive ways of detecting potential instructional problems existing in the Navy and (2) recommend means to minimize performance deterioration by restructuring training and job conditions.

This is the seventh report concerned with skill deterioration. Previous reports described long-term retention of factual information in the Propulsion Engineering Basics Course, the effects of different instructional strategies on long-term retention of materials taken from that course, existing research relevant to skill and knowledge loss, a survey of the three Navy sonar communities--aviation, subsurface, and surface--to identify conditions leading to skill loss, and assessments of job and training variables leading to skill loss in sonar technicians (surface) (STGs) and aviation antisubmarine warfare operators (AWs) (NPRDC TN 80-5, TR 81-22, SR 82-21, SR 83-18, SR 83-26, and SR 83-28). Assessments were conducted using a job condition questionnaire. This report describes skill deterioration that occurs in the AW training pipeline because of long nonutilization periods.

Results of this work are intended primarily for the Common Core Acoustic Analysis School, Fleet Aviation Specialized Operational Training Group, and the Fleet Replacement Squadron (FRS) (VS-41). The results should also be of interest to other agencies concerned with sonar operator training.

Appreciation is expressed to the instructors at the Acoustic Analysis School and the FRS for their cooperation in this research effort.

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SUMMARY

Problem

In the aviation sonar community, aviation antisubmarine warfare operator (AW) students in the S-3A training pipeline receive 4 weeks of basic training in methods of acoustic analysis, integration of acoustic intelligence information, and target classification procedures at the Common Core Acoustic Analysis School, Fleet Aviation Specialized Operational Training Group (FASOTRAGRU). Although acoustic analysis procedures are complex, requiring the support of an extensive, complicated knowledge base, they are not practiced for approximately 1 month (25 days) prior to additional acoustic analysis training at the follow-on operator course conducted at the Fleet Replacement Squadron (FRS) (VS-41), FASOTRAGRU. The degree of skill and knowledge retention following this 1-month task nonutilization period needs to be established.

Objective

The objective of this work was to determine if AWs retain the skills and knowledge required for satisfactory performance of acoustic analysis and classification over the 25-day nonutilization period between a basic acoustic analysis course and the follow-on operator course.

Approach

Subjects were 20 AWs in the S-3A training pipeline who attended both the FASO acoustic analysis course and the follow-on FRS operator course. The original learning measure was the acoustic analysis course final examination, comprised of (1) a multiple-choice knowledge exam consisting of both factual and computational items, and (2) a performance test that examined student performance of acoustic analysis and classification procedures on static linear lofargrams. The retention measure, administered approximately 1 month later, consisted of alternate forms of the original measure. Acoustic analysis course instructors judged that the questions on the knowledge test and the lofargrams used in the performance test on the two measures were of equal difficulty. The tests were graded by the experimenters using standardized grading criteria developed by subject matter experts.

Findings

Students performed better on the measure of original learning than on the retention tests for most of the variables analyzed. Significant differences for the two test administrations were found for all scores on the knowledge test (overall, the factual test items, and the computational test items) and for performance for the analysis variables on the performance test. No significant differences were found for the classification variable.

Conclusions

Over the 25-day nonutilization period, the knowledge factors, computational skills, and gram analysis procedures of students in the S-3A acoustic analyst training pipeline degraded significantly.

Recommendations

1. Students should be provided opportunities to practice newly learned skills and receive corrective feedback for errors during periods of transition between schools whenever possible. If practice cannot be provided during these periods because of classified material or equipment requirements, refresher training should be built into the curriculum of the follow-on school.

2. Instructional methods should be investigated to determine if retention of complex procedural tasks is influenced by type of instruction.

3. Lofargrams that are to be used on tests for performance evaluation should be obtained from gram libraries other than those used in that training environment to help eliminate the tendency for students to classify targets by pattern recognition.

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INTRODUCTION

Problem

Personnel in technical ratings must have an extensive technical knowledge base and be proficient in performing complex procedural tasks to be able to perform their jobs. Personnel in technical ratings are trained through a series of schools (training pipeline) before they are deployed to the fleet. The skills and knowledge gained in the basic schools are required for successful performance in the more advanced schools. However, in most cases, those skills are not practiced during the transition period between schools; they usually are not practiced until that point in the advanced school's curriculum where that specific subject matter is addressed. The length of this nonutilization period is influenced by geographic distance between the schools, the number of available seats in the follow-on school, and enrollment in courses that emphasize training of other job-related skills.

The length of task nonutilization periods has been identified as one variable associated with losses in skill proficiency (Annett, 1977; Gardlin & Sitterley, 1972; Hurlock & Montague, 1982; Naylor & Briggs, 1961; Prophet, 1976; Schendel, Shields, & Katz, 1978). The other variables identified were type of task, level of original learning, amount of practice, and the adequacy of performance feedback.

Complex procedural skills and extensive fact-based knowledge structures have been found to be vulnerable to skill loss. Wetzel and Montague (1983) interviewed subject matter experts in the Navy's three sonar communities--aviation, subsurface, and surface--as to sequence of formal training, types of training, job activities, and feedback conditions provided to sonar personnel. They found that aviation antisubmarine warfare operators (AWs) assigned to the aviation community's S-3A platform are highly trained. About 6 weeks after they graduate from AW "A" school, they report to a Fleet Aviation Specialized Operational Training Group (FASOTRAGRU) for 20 weeks. The first 4 weeks are spent in the AW common core acoustic analysis course, where AWs receive training in acoustic analysis, integration of acoustic intelligence information, and target classification procedures. These procedures are complex, and the knowledge base that supports the procedures is extensive, fact-based, and complicated. Immediately following completion of the common core course, they attend a follow-on operator course at the Fleet Replacement Squadron (FRS) (VS-41). The initial 3 weeks of FRS training focuses on equipment familiarization and does not include practice or review of acoustic analysis procedures or acoustic intelligence information. Following this period, students begin operator training on the OL-82 sonar system simulator and are expected to perform the procedural skills and recall from memory the acoustic intelligence information learned several weeks earlier. The degree of skill and knowledge following a period of task nonutilization needs to be established to determine the training and job conditions required to maintain such skill and knowledge adequately.

Objective

The objective of this work was to determine if AWs retain the skills and knowledge required for satisfactory performance of acoustic analysis and classification over the 25-day nontraining period between a basic acoustic analysis course and the follow-on operator course.

Background

This research effort focuses on the performance of students who are in training to become passive acoustic analysts and their retention of the complex procedures and fact-based knowledge structures required for performing acoustic analysis. Chi, Glaser, and Rees (1981), in comparing the performance of novices and experts on complex tasks, found that skilled individuals are better able to remember task-specific information. Studies on electronic technicians (Egan & Schwartz, 1979), architects (Akin, 1980), and computer programmers (Jeffries, Turner, Polson, & Atwood, 1981) also identified differences in the information structures of novices and experts. In essence, they found that the greater the information an individual has about a set of procedures and the more familiar he or she is with those procedures, the better his/her knowledge about them is structured. The better structured the knowledge, the more likely that an individual can recall correct information in the appropriate sequence required to complete the task. The major point here is that novices may be particularly vulnerable to forgetting learned skills and knowledge over periods of time when the task is not practiced, because their knowledge is relatively unstructured. Newly trained sonar operators in transit, assigned to other tasks, or involved in training for other tasks may forget important information quite rapidly. This effort examines the forgetting of acoustic analysis skills and knowledge during a period of time when the student is involved in other training.

APPROACH

Subjects

The subjects were 20 AWs in the S-3A training pipeline who attended both the FASO acoustic analysis course and the follow-on FRS operator course.

Test Materials

The original learning measure was subject performance on the acoustic analysis course final examination. This examination was comprised of a 40-item, multiple-choice knowledge test and a gram analysis/classification performance test. The knowledge test included (1) factual items that required subjects to recognize information about oceanography, acoustic intelligence, and principles of the physics of sound transmission and (2) computational items that required them to recall acoustic intelligence, select appropriate formulas, and perform mathematical manipulations. The performance test required subjects to document their analysis procedures in classifying five static linear lofargrams. In all, six scores were derived for each subject--three on the knowledge test (total score, factual items, and computational items) and three on the performance test (gram analysis, gram classification, and systematic analysis).

The retention measure consisted of alternate forms of the acoustic analysis course final examination. Course instructors matched the level of difficulty of the lofargrams used on original learning and retention measures by applying standards determined by the lofargram difficulty index.

Procedure

Acoustic analysis course final examination data were collected for from six to eight subjects from three consecutive classes who had subsequently enrolled in the follow-on FRS operator course. Twenty-five days after subjects graduated from the acoustic

analysis course, they were administered the retention test. None had received additional training in acoustic analysis procedures in the interim period.

The original learning and retention measures were scored by the experimenters using grading criteria developed by acoustic analysis course instructors. For each measure, an analysis of covariance was computed, using subjects' armed forces qualification test (AFQT) score as the covariate.

FINDINGS

Table 1 presents an analysis of covariance summary table for the knowledge and performance measures. As shown, subjects performed significantly better on the knowledge test and on gram analysis and systematic analysis procedures in the original test than they did in the retention test. The difference in scores between the two test administrations for accuracy of target classification failed to reach statistical significance.

Table 1

Analysis of Covariance Summary Table for the Knowledge and Performance Tests

Source	Degrees of Freedom	Mean Square	F
Knowledge Test:			
Total	1	313.60	28.86**
Error	19	10.86	
Fact	1	44.10	5.90*
Error	19	7.46	
Computation	1	90.00	39.76**
Error	19	2.26	
Performance Test:			
Gram analysis	1	714.02	11.30**
Error	19	63.14	
Gram classification	1	75.62	2.67
Error	19	28.25	
Systematic analysis	1	387.50	
Error	19	9.97	38.82**

Note. The armed forces qualification test score was the covariate.

*$p < .05$.
**$p < .01$.

Table 2 provides percentages, raw score means, and standard deviations for the knowledge and performance measures. Subjects' overall performance on the knowledge test dropped from 85 percent to 72 percent; and their performance on the factual and computational items dropped from 86 and 81 percent respectively to 79 and 56 percent. On the performance test, their performance in gram and systematic analysis dropped from 87 and 77 percent respectively to 77 and 61 percent. Finally, their classification accuracy performance on the original test was 85 percent correct, compared to 74 percent on the retention test.

Table 2

Means and Standard Deviations for Original Learning and Retention Measures

Test/Score	Measure					
	Original Learning			Retention		
	%	$\bar{X}$ Raw Score	SD	%	$\bar{X}$ Raw Score	SD
Knowledge						
Total (Max. score = 40)	85.00	33.90	2.30	71.60	28.30	5.40
Fact (Max. score = 28)	86.10	24.10	3.10	78.60	22.00	4.60
Computation (Max. score = 12)	80.80	9.70	1.10	55.80	6.70	2.10
Performance						
Gram analysis (Max. score = 80)	86.90	69.50	6.30	76.30	61.10	9.70
Gram classification (Max. score = 25)	85.00	21.30	3.90	74.00	18.50	5.80
Systematic analysis (Max. score = 40)	76.80	30.75	2.90	61.30	24.52	2.90

Tables 3 and 4 provide knowledge and performance test score frequencies for the original learning and retention measures. Note that, on the original measure, all 20 of the students were able to answer at least 7 of the 12 computational items correctly, compared to 10 students on the retention test. On the analysis task in the original performance test, 17 of the 20 students were able to answer at least 65 of the 80 items (81%) correctly, compared to 6 students on the retention test, given less than 1 month later. Further, on the systematic analysis procedure, 13 of the 20 subjects were able to answer at least 75 percent of the items correctly on the original measure, but none could perform that well on the retention mesure.

Table 3

Knowledge Test Score Frequencies for Original Learning and Retention Measures

Total (Max. score = 40)			Fact (Max. score = 28)			Computation (Max. score = 12)		
Score	f	%	Score	f	%	Score	f	%
Original Learning Measure								
39-40	0	0.0	27-28	2	10.0	11-12	5	25.0
37-38	5	25.0	25-26	5	25.0	9-10	13	65.0
35-36	1	5.0	23-24	9	45.0	7-8	2	10.0
33-34	7	35.0	21-22	3	15.0	≤6	0	0.0
31-32	7	35.0	≤20	1	5.0			
≤30	0	0.0						
Retention Measure								
37-40	0	0.0	27-28	0	0.0	11-12	0	0.0
35-36	2	10.0	25-26	4	20.0	9-10	5	25.0
33-34	3	15.0	23-24	5	25.0	7-8	5	25.0
31-32	3	15.0	21-22	5	25.0	5-6	7	35.0
29-30	2	10.0	≤20	6	30.0	3-4	3	15.0
27-28	4	20.0				≤2	0	0.0
25-26	2	10.0						
23-24	2	10.0						
21-22	0	0.0						
≤20	2	10.0						

Table 4

Performance Test Score Frequencies for Original Learning and Retention Measures

Gram Analysis (Max. score = 80)			Gram Classification (Max. score = 25)			Systematic Analysis (Max. score = 40)		
Score	f	%	Score	f	%	Score	f	%
Original Learning Measure								
75-80	4	20.0	25	8	40.0	37-40	0	0.0
70-74	9	45.0	20	10	50.0	34-36	5	25.0
65-69	4	20.0	15	1	5.0	31-33	8	40.0
60-64	1	5.0	10	1	5.0	28-30	3	15.0
55-59	1	5.0	≤5	0	0.0	25-27	4	20.0
50-54	1	5.0				≤24	0	0.0
≤49	0	0.0						
Retention Measure								
75-80	1	5.0	25	5	25.0	37-40	0	0.0
70-74	4	20.0	20	9	45.0	34-36	0	0.0
65-69	1	5.0	15	2	10.0	31-33	0	0.0
60-64	6	30.0	10	3	15.0	28-30	4	20.0
55-59	3	15.0	≤5	1	5.0	25-27	6	30.0
50-54	3	15.0				22-24	7	35.0
≤49	2	10.0				19-21	2	10.0
						≤18	1	5.0

DISCUSSION AND CONCLUSIONS

Although subject performance degraded significantly between the two test administrations on the knowledge test and on the analysis part of the performance test, it did not decline significantly in classification skills. This may be due to pattern recognition since the lofargrams used on both the original learning and retention measures were selected from a limited number of grams available in the training library at the acoustic analysis school. Test scores may be more reflective of the subject's ability to remember familiar visual patterns than to use systematic procedures to analyze and classify acoustic signatures, particularly in light of subjects' significant loss of skill in the analyses procedures. This may indicate that the underlying structure of the student's understanding of acoustic analysis may not be organized to optimize information retention. In discussions with the subjects following the retention tests, they reported that they had trouble analyzing the lofargrams but that they remembered the patterns of the grams and were able to recall the classification from memory. A more valid evaluation of the subject's ability to classify targets would be obtained by using grams that had not been previously encountered.

Subjects forgot significant amounts of their acoustic analysis skills and knowledge during the 25-day nonutilization period, which represents a relatively short amount of time. Task nonutilization periods that include time spent in transit, in doing or studying other tasks, and on leave are often much longer than 25 days for personnel in technical training pipelines. It is very likely that knowledge and skill degradation has significant impact on the student's initial level of performance in advanced schools that require the use of complex procedures learned in the basic schools.

In many ratings, students find it difficult to practice procedures learned previously, even when they are highly motivated to do so, because of the lack of specific equipment, classified information, or other specific requirements. In this situation, refresher training in the follow-on school seems to be the most logical solution to this problem.

RECOMMENDATIONS

1. Students should be provided opportunities to practice newly learned skills and receive corrective feedback for errors during periods of school transition whenever possible. If practice cannot be provided during these periods because of classified material or equipment requirements, refresher training should be built into the curriculum of the follow-on schools. Also, present Navy policies concerning leave, class scheduling, and other interruptions of the training pipeline should be evaluated with the goal of reducing the length of task nonutilization periods.

2. Instructional methods should be investigated to determine if retention of complex procedural tasks is influenced by type of instruction.

3. Lofargrams that are to be used on tests for performance evaluation should be obtained from gram libraries other than those used for training purposes. This should help eliminate the tendency for students to classify targets by pattern recognition rather than analysis techniques.

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