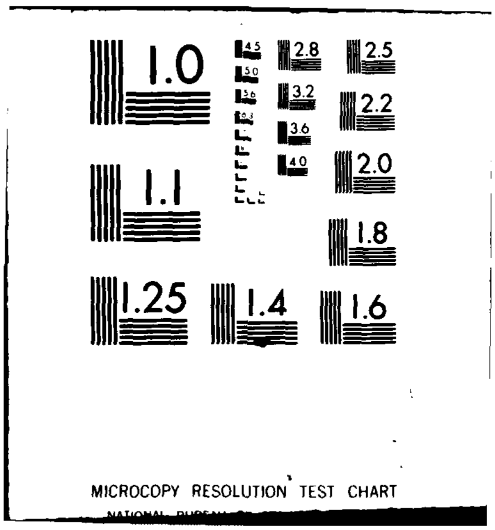
1.0
1.1
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1.4
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4.0
MICROCOPY RESOLUTION TEST CHART

NPRDC TR 82-25 January 1982

RELATIONSHIPS BETWEEN COMMUNICATION VARIABLES AND SCORES IN TEAM TRAINING EXERCISES

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As investigation was made of the practicality of assessing anti-submarine warfare (ASW) team performance by means of measures of the volume of communications. A system for classifying communications was developed based on an analysis of published data on communication rates (e.g., number of evaluative messages sent per minute) of ASW helicopter crews. Next, communications were recorded for ship's teams during two exercises in the 14A2 ASW team trainer. Communication rates were computed for various types of messages over the ship-to-ship and ship-to-air circuits. Rates were

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compared against instructor grades for individuals, subteams, and teams. Communication rates on the intership circuit tended to be negatively correlated with grades, primarily because instructors gave lower grades to teams doing excessive talking. Rates on the ship to air circuit were positively correlated with performance on the later exercise where two aircraft were used rather than one and where a much greater volume of information needed to be transmitted. On the internal circuits, few significant relationships were found between communication rates and performance. Implications of the findings for development of an objective performance measurement system for team training are discussed.

FOREWORD

This research and development was done under task area ZF63-522-001-010 (Developments in Technology for Applications in Training and Education), work unit ZF63-522-001-010-03.02 (Team Training for Tactical Environments). A major goal of the work unit is to develop an objective performance assessment system for antisubmarine warfare team training exercises.

This effort investigated the feasibility of using objective, quantitative measures of team communications (e.g., amount of information sent per minute on the 61JS sonar circuit) for assessing team performance. There are several indications from prior research that such communication rates are related to team effectiveness. The project demonstrated that such relationships exist for surface ship ASW but are not strong enough for communication rates to be used by themselves as effective measures of team performance. The analysis also indicates that a single measure of combat team performance, such as weapon accuracy, is of limited importance in team assessment because of the complexity of ASW team exercises. Composite measures are needed that reflect the many significant responses that a team must make to perform effectively.

Data from this effort were used to assist in development of ASW team training objectives (NPRDC Tech. Note 81-18 and Spec. Rep. 82-4).

Results of this work are intended primarily for the Fleet Anti-Submarine Warfare Training Center, Pacific, and for other agencies concerned with surface ship ASW training. The results should also be of interest to the Chief of Naval Education and Training, the Chief of Naval Operations (OP-01), and the research and development community concerned with team training.

Appreciation is expressed to personnel of the Fleet Anti-Submarine Warfare Training Facility, San Diego, who were instrumental in facilitating the gathering of data and providing advice on technical matters. Particular appreciation is extended to CAPT R. F. Comer, for his support; to OSCM Lowell Johnson, STGCS Wayne Gangstad, STGC Gerald Phillips, STGC William Clark, and ST2(CG) John Cossett for their personal guidance; and to CDR Richard Ellis, LT Ray Van Dyke, and LCDR Joseph Dobson for their administrative support throughout the research period.

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SUMMARY

Problem

Current methods of assessing the performance of individuals and teams during team training are highly subjective. Objective methods are needed to ensure instructor agreement on grading criteria and to provide specific information to teams on performance requirements and training achievement.

Purpose

The purpose of this effort was to evaluate the importance of team communication measures for assessing performance of antisubmarine warfare (ASW) teams and subteams during team training exercises.

Approach

An initial study was conducted to identify useful criterion measures of team performance. Data were gathered on ASW teams from escort ships who were undergoing qualification training in the 14A2 ASW single ship team trainer. The ASW subteams included were those in the combat information center, underwater battery plot, sonar, and bridge. Subteam and individual performance and weapon accuracy were assessed by instructors using a detailed checklist.

Next, published data on communications of ASW helicopter crews were analyzed to evaluate the feasibility of using communications measures for assessing performance. A revised system for classifying communications was developed. This system, which classifies messages into information, questions, responses to questions, affirmations (repetition) of information, evaluations, directions, and other, was applied to data collected from 14A2 exercises for 16 ships' teams. Recordings were made of voice transmissions over the 1JS (command), 61JS (sonar), R/T2 (ship to ship) and R/T3 (ship to air) circuits. Message rates (amount of information per minute) were determined for different types of messages and compared to instructor scores for individuals and subteams.

Findings

In the initial study, the checklist appeared to be sensitive to team effectiveness, as indicated by improvement over trials, but considerable difficulties were found in its use. Also, weapon use was found to be an unsatisfactory measure of team performance because of wide variation in number of weapons fired and lack of relationships with other performance measures.

In the communications study, a number of significant correlations were found between message rates and performance scores, with the higher correlations tending to occur for external communications (on the RT/2 and RT/3 circuits) and for the communication categories of information, responses to questions, and evaluations. These relationships generally do not seem to be strong enough for communication rates to be used as direct measures of performance.

Conclusions

Instructor grades appear to be related to team communication rates but quantitative measures of team communications are not useful by themselves for assessing team

performance. Quality and timeliness of communications appear to be more appropriate measures for scoring team and individual performance.

A composite scoring system, sensitive to the multiple events occurring in ASW exercises, is needed for assessment and feedback during ASW team training. For maximum objectivity and accuracy, the system should employ a checklist that can be completed during the course of an exercise.

Recommendations

1. An objective performance checklist should be developed for use in 14A2 ASW training exercises and for grading Phase I qualification exercises. Particular attention should be given to assessing the timeliness and quality of communications.

2. Research and development should be conducted to provide the necessary information to develop a performance checklist that accurately reflects training objectives. Data taken from existing tapes of communications collected for this report should be used to assist in developing the objectives and checklist.

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INTRODUCTION

Problem

Performance assessment in most current team training is highly subjective (Hall & Rizzo, 1975; Wagner, Hibbits, Rosenblatt, & Schutz, 1976). Hall and Rizzo concluded that "clearly stated, objective criteria and procedures for evaluating team performance are apparently not available" (p. 43). Objective methods are needed to ensure instructor agreement on grading criteria and to provide detailed feedback to teams and team members. In the area of antisubmarine warfare (ASW), there are two key problems in the objective assessment of team performance: (1) the development of appropriate measures of team communications, and (2) the determination of useful overall measures of team performance.

Purpose

The primary objective of this effort was to evaluate the usefulness of quantitative measures of the volume of different types of communications in surface ship ASW training exercises. Supporting objectives were (1) to evaluate existing criterion measures of team performance, and (2) to develop a system for classifying communications and measuring their volume.

Background

This work is part of a program to develop objective performance measures for team training. The project examined team performance during exercises in the 14A2 single-ship ASW team trainer. The 14A2 trainer is used during Phase I of the Escort Qualification Program to qualify ships for escort duty.

An objective performance measurement system has a number of requirements. A measure of overall team performance such as weapon accuracy is not enough by itself for assessing 14A2 team performance because of the complexity of the exercises. A composite scoring system is needed that reflects the responses of individuals and subteams to all of the critical events in an ASW problem. The system must provide extensive coverage of communications because communications are essential to ASW operations and are of high frequency. In earlier work in this project, Bell (in press) identified a number of potentially useful objective measures of performance in 14A2 training. Most of these measures were concerned with correctness of procedures and time and accuracy of team and member actions. There were few available measures of team communications. Bell did find that frequency of communication errors by the tactical communicator (TACCOM) was negatively correlated with instructor grades for the TACCOM.

Previous attempts to find important quantitative measures of communications have been only moderately successful. It appears that overall communication rates are unrelated to team performance (Siskel, 1965; Fineburg, 1974). There have been several attempts to find relationships between team effectiveness and message rates in various subcategories of communications. Krumm and Farina (1962), in a study of simulated B-52 bombing missions, identified four principal communication categories (other than identifications and acknowledgements): requests, responses to requests, voluntary communications, and orders. They found that voluntary communications increased with training and were directly related to bombing and navigation accuracy and to instructor rankings of crew coordination.

Briggs and Johnston (1966, 1967) investigated the communications of air intercept controllers in simulated antiair warfare. Using results of a factor analysis, they identified three major communication categories: (1) declarative messages, based on information from the radar scope, (2) tactical messages, based on information not on the scope, and (3) tactical commands. In a series of experiments, Briggs and Johnston found few significant correlations between team performance and volume of communications in these categories. Most of the significant relationships were negative, indicating a need for restraint in communications. Only where communications appeared to be essential (e.g., when information on the scope was restricted) was there a positive relationship.

Federman and Siegel (1965) analyzed communications during ASW helicopter missions. These data are important because they deal with ASW and because Federman and Siegel employed a number of communication measures not used by previous investigators. They performed a factor analysis of the measures and found four factors related to weapon miss distance. They labeled the factors (1) probabilistic structure (messages reflecting uncertainty and the weighing of probabilities), (2) evaluative interchange, (3) hypothesis formulation, and (4) leadership control. However, their analysis is suspect because they used a number of variables that were ratios of other variables within the analysis. This amounts to giving these variables an arbitrarily high weight in the factor analysis. A more appropriate analysis is needed to identify useful categories of ASW communications.

Federman and Siegel (1965) also measured time to detect the submarine, time to initiate changes in sonar dip location, dip to dip accuracy, and weapon miss distance in exercises of varying difficulty. Only miss distance was related to difficulty. The usefulness of miss distance for surface ship ASW needs to be checked.

APPROACH

1. Criterion performance measures available on the 14A2 team trainer were analyzed to identify useful measures of team and subteam performance. Such measures are needed not only to determine team readiness but also to evaluate the validity of proposed performance measures such as communication rates.

2. The Federman and Siegel data were reanalyzed to identify useful measures of ASW communication rates.

3. A study was made of ASW communication rates and team performance in 14A2 exercises to determine whether quantitative measures of ASW communications could be used for performance evaluation.

PRELIMINARY ANALYSIS OF CRITERION MEASURES

ASW Exercises

The 14A2 exercises studied were search-attack unit (SAU) exercises. SAU exercises provide a simulation of the crew's own ship, a high value unit (HVU) that they are assigned to protect, an assist ship with which their ship must operate, one or two helicopters used to support the operations, and an enemy submarine whose primary goal is to attack the HVU. The HVU and assist ship, the two aircraft, and the submarine are maneuvered by instructors. Ship and aircraft maneuvers, weapon use, etc., occur in a free play mode starting from preprogrammed initial positions. Communications between crew members, the

HVU, the support ship, and the aircraft simulate actual operations. The instructors act as the communicators for the external units.

SAU exercises provide training for crew members in the combat information center (CIC), sonar, underwater battery (UB) plot, and bridge. Personnel in CIC include the evaluator, who directs ASW operations; the tactical communicator (TACCOM), who communicates with the other ships; the antisubmarine air controller (ASAC), who directs ASW aircraft operations; geographic plotters; and a few others. Sonar includes the sonar supervisor and operators. Personnel in UB plot are the ASW officer and operators.

Procedure

Instructor grade sheets were collected for 12 ships' teams taking the 3-day escort qualification course in the 14A2 trainer. Instructors used a checklist to score the exercises. The checklist provided evaluation of specific actions taken by team members or subteams. Scores on the separate items were added for each team member and then weighted to determine the team score. The weights used were as follows:

1. Evaluator--40 percent
2. ASAC--16 percent
3. CIC--12 percent
4. Sonar--8 percent
5. UB plot--12 percent
6. Bridge--2 percent
7. Weapons use--10 percent

Scores for teams and individual positions were examined for exercise 5, exercise 12, and the final grade. Exercise 5 used a SAU composed of own ship, assist ship, and a Lamps helicopter. Exercise 12 added a sonar dipping helicopter to the SAU. In the final grade, the last exercise counted 40 percent, and the previous exercises together counted 60 percent. At the time of this study, there were usually 12 exercises, although some of the initial exercises might not be graded.

Results

The weighted instructor scores for checklist items were converted to percentages to permit comparisons between individuals and subteams. Results are shown in Table 1.

An important feature of the checklist was that it provided useful information on performance at a variety of levels: teams, subteams, individual positions, and specific subteam or member actions. For example, since sonar and UB plot operators scored higher than all other individuals and subteams on trial 5, it appears that these operators tend to reach satisfactory proficiency levels more quickly than other team members. Other team members, except for the ASAC, showed large improvements in performance from exercise 5 to the final exercise. Most of these improvements were statistically significant (t for paired measures), despite the small sample size. In some cases, the standard deviation decreased, indicating greater uniformity among ships.

The contributions of subteam scores to team scores are shown by the correlations in the top part of Table 2. Correlations were highest for the evaluator, as might be expected since his score counted 40 percent of the team score. Sonar and UB plot scores were not significantly correlated with team score on either exercise 5 or the final grade.

Table 1

Percentage Score on Instructor Checklist
in Preliminary Study

Item	Exercise 5		Final Exercise	
	Mean	S.D.	Mean	S.D.
Evaluator				
General	58.8	16.8	79.9**	13.7
Approach	73.5	17.5	85.7	13.5
Attack	73.8	22.6	79.9	18.8
ASAC	76.5	15.1	80.0	10.0
CIC				
TACCOM	76.8	18.5	90.4**	9.0
Other	74.3	12.2	90.3**	6.3
Sonar				
Supervisor	69.7	15.7	83.1**	14.6
Operators	84.5	12.5	89.3	14.0
UB Plot				
ASW Officer	73.2	11.4	86.2*	10.0
Operators	85.5	20.1	96.0	7.4
Bridge	79.6	15.7	93.1	12.8
Weapons	73.0	29.6	58.3	36.9
Average	74.9	--	84.4	---

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

Table 2

Correlations of Subteam Scores with Criterion Scores
in Preliminary Study

Criterion Score	Subteam					
	Eval.	ASAC	CIC	Sonar	UB Plot	Bridge
Team Total:						
Exercise 5	.88**	.63*	.80**	.04	.32	.32
Final Grade	.85**	.73**	.78**	.48	-.30	.86**
Evaluator:						
Exercise 5	--	.23	.53	-.11	.32	.11
Final Grade	--	.69*	.59*	.59*	-.45	.65*
Weapons Use:						
Exercise 5	.49	.37	.52	-.47	-.06	.49
Final Grade	.23	.35	.45	-.06	-.33	.56

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

Subteam scores tended to be poorly correlated with each other except that there was a strong tendency for evaluator scores to be correlated with other subteam scores on the final grade. The evaluator is the key person on the ASW team. The data suggest that performance on the better teams is partly due to better coordination of team activities by the evaluators.

No significant correlations were found between weapons use scores and any of the scores for subteams. The weapons score was based on miss distance of both ASROC and directed helicopter attacks. A ship might attack from one to four times in an exercise, depending on both tactical conditions and team skill. Occasionally, a ship might not be able to fire at all. Thus, weapon accuracy seems to be of minor importance for assessing team performance in the 14A2 trainer.

An analysis of the content of the checklist revealed that half of the 126 items dealt partially or totally with communications, and a number of other items also reflected the great importance of team communications in ASW operations. Most of the checklist items were objective in nature, requiring only comparison against a known standard (e.g., "Was Doppler reported accurately?"). Some items depended heavily on expert judgment (e.g., "Did the evaluator keep firm control of and order correct tactics for all air assets?"). Over half of the evaluator grade depended on this type of item. Checklists were filled out at the end of the exercise, a practice that tends to reduce reliability and objectivity. It is highly desirable to have an objective system where performance standards are written down and evaluation is done during an exercise. Such a system is advantageous, since it ensures instructor agreement on evaluation criteria, is useful for training of new instructors, and can be used to provide explicit information to teams on what is expected of them.

In summary, both team and subteam scores on the checklist appear to be important criterion measures for evaluating the usefulness of proposed communication measures. Weapon accuracy, however, does not seem to be useful for the very complex ASW exercises studied here.

DEVELOPMENT OF CLASSIFICATION SCHEME FOR SURFACE SHIP ASW COMMUNICATIONS

Method

Federman and Siegel collected communication data for 24 ASW helicopter crews, developed 27 measures of communication rates, and used the 14 measures that correlated most highly with weapon miss distance for their factor analysis. Fourteen is a rather large number of variables for a factor analysis based on data from only 24 crews. Further, several measures were redundant and others were formed by ratios of other variables, which gave undue weight to these measures. Therefore, the Federman and Siegel data were reanalyzed, using a principal factors equimax rotation, to reduce redundancy among variables and keep the number of variables to a reasonable size. Derived variables, such as the ratio of two measured variables, were eliminated to give appropriate weight to the original measures. Federman and Siegel also classified individual communications in more than one way (e.g., "Information Response" and "Phenomenological"), giving additional weight to these communications. Some of these dual classifications were eliminated on the basis of a partial correlation analysis. Finally, four measures were eliminated that occurred less than 1/2 of 1 percent of the time. As a result, only nine variables were included in the new factor analysis.

Results

Factor analysis of the nine communication variables selected from the Federman and Siegel data resulted in the identification of five factors, which are presented in Table 3. The Eigenvalues and percent of variance figures indicate the relative importance of the factors. The makeup of the first four factors suggested that they should be labelled direction, data assimilation, data acquisition, and prediction (or evaluation). The fifth factor is of lesser importance but is most closely associated with responses to requests for information.

Factor 1, direction, covers messages expressing a need for timely action, such as orders and recommendations. The variables of activity and extrapolation have the strongest loadings on this factor. Examples given by Federman and Siegel indicate that messages in these categories often have a strong directive component (e.g., activity: "Recommend you jump east now"; extrapolation: "The sub's going south at 10 knots, so fly south at 90 knots and we'll be over him in 62 seconds").

Factor 2, data assimilation, reflects the need for the team members to absorb the meaning in data. The principal contributing variables are corroboration ("I understand, 080 break 22"), voluntary information, and interpolation.

Factor 3, data acquisition, covers messages that emphasize the need to fill in gaps in existing data. The major variables are requests for information and interpolation.

Table 3

Factor Loadings for Federman and Siegel Data

Variable	Direction 1	Data Assimilation 2	Data Acqusition 3	Prediction or Evaluation 4	Requests for Information 5
Activity	.89	.05	.06	-.04	-.02
Corroboration	.15	.73	.18	.07	.02
Request Information	.12	-.59	.75	.21	.06
Information Response	-.08	-.02	-.03	-.03	.71
Voluntary Information	-.07	.36	-.02	-.10	-.02
Voluntary Opinion	-.04	-.05	.03	.83	.01
Interpolation	-.45	.39	.60	-.05	.24
Extrapolation	.41	.00	-.15	.39	.56
Repeated Message	.03	.07	.28	-.02	-.16
Eigenvalue	1.45	1.25	1.06	.87	.65
% of Variance	28	23	20	17	12

Factor 4, prediction or evaluation, covers messages that predict events or evaluate the outcome of actions. This factor loads most heavily on voluntary opinion and, to a lesser extent, on extrapolation. Note that the example of voluntary opinion given in Federman and Siegel, "He should be due north of you," could also be classified as extrapolation.

The Federman and Siegel procedure of classifying messages in more than one category seems to be counterproductive. For instance, the definitions and examples of interpolation and extrapolation indicate that messages in these categories could be classified in a number of other ways. In the factor analysis, interpolation and extrapolation were not simply related to the performance criterion but, instead, each loaded on several factors. On the basis of this analysis, the set of seven categories listed below was developed for analyzing ASW communications. Six of the categories are similar to the variables in the factor analysis that loaded primarily on only one factor (voluntary information, requests, responses, corroboration, voluntary opinion, and activity). The categories have the desirable property of being mutually exclusive and exhaustive (when applied to individual message units rather than the total message).

1. Information. Messages that transmit information essential to keeping track of events or controlling operations (e.g, "Target bears 145, at 8500 yards"). This category

covers "voluntary" information and does not include responses to questions or affirmations of received data.

2. Questions. Requests for information, intentions, opinions, etc. (e.g., "What is your present position?").

3. Responses. Answers to questions.

4. Affirmations. Repetition of information received (e.g., "Roger. Read your bearing 140, range 7900 yards"). Classified as "Other" if the information is repeated incorrectly.

5. Evaluations. Messages that evaluate the tactical situation or some phase of it (e.g., "I hold the target headed northwest at slow speed"). An immediately following, "I concur," would also be classified as evaluation.

6. Directions. Directions regarding actions, including orders, commands, and strong suggestons that have the effect of directing (e.g., "Recommend you come right to 040 degrees").

7. Other. Messages that cannot be placed in the other six categories, including call signs, irrelevant information, facetious remarks, etc.

This system for categorizing communications was used in the analysis to identify relationships between communication rates and team performance. During this analysis, it was found that message units could be classified consistently in these categories with a relatively small amount of practice.

IDENTIFICATION OF RELATIONSHIPS BETWEEEN COMMUNICATION RATES AND TEAM PERFORMANCE

Subjects

The subjects were 16 crews taking the 1070 qualification course or the 1032 training course in the 14A2 trainer. The makeup of the crews was highly variable, some members having had no previous experience in team ASW operations. Four of the 14 crews scheduled for the 1070 course were considered to be unprepared by the instructors, and they were changed to the 1032 training courses. In addition, data for two crews voluntarily doing 1032 training were added to increase the sample size. The 1032 and 1070 courses used basically the same exercises and were scored in the same way by the instructors.

Procedure

During this study, the 1070 course was 2 days in length and covered seven exercises. Exercises 3 and 7 were selected for study to measure changes in performance. Exercise 3 included an assist ship, a Lamps helicopter, and an enemy submarine. Exercise 7 added a sonar dipping helicopter but was otherwise essentially the same. The 1032 exercises that were recorded had the same scenerios as these exercises.

A four-channel tape recorder was used to record communications over the four critical communication networks: (1) the 1JS, the principal command channel aboard ship, (2) the 61JS, the sonar reporting network, (3) the R/T2 radio transmission net, linking the ship to the support unit and high value unit, and (4) the R/T3 net, linking the ship with the support aircraft.

Measures

Communications were divided into distinct message units. A message unit was defined as that portion of a communication that transmitted a single item of data. For example, the bearing to a target, an identifying call sign, particular descriptive data, such as "my latest," etc., were classified as individual message units. Each message unit was classified into one of the seven categories obtained from the reanalysis of the Federman and Siegel data (i.e., information, questions, responses to questions, affirmations, evaluations, directives, or other).

Audio tapes were made for each ship, and then played back and "read" to count the number of message units in each communication. For consistency, all tapes were read by one individual. The number of message units in each category was divided by the duration of the exercise to establish communication rates, except that the duration of sonar contact was used to establish communication rates over the 61JS net. These data were then correlated with instructor grades.

The grading system was different from that used in the preliminary study. The checklist was no longer used and separate scores for the bridge and weapons use were no longer computed. At the end of each exercise, the instructors assigned subjective scores to the evaluator, ASAC, and TACCOM, and to the CIC, sonar, and UB plot subteams by awarding a portion of a specified maximum score (e.g., 40 for the evaluator). These scores were added together to produce a team exercise score (maximum = 100). Final grades were established by averaging the scores for all seven exercises. A final grade of 62.5 was required for qualification.

Results

The mean number of message units transmitted per minute over the four communication circuits included in this analysis are shown in Table 4. There was a wide variation in message rates in the various communication categories. Rates were highest in the information category, as might be expected where the activities of several ships, aircraft, and subteams must be coordinated. Directions were also frequent except over the 61JS circuit, which is basically a reporting circuit for sonar.

For the RT/3 air control circuit, there was a significant increase in volume of communications from exercise 3 to exercise 7 in all categories except affirmations and evaluations. The reason for this increase is that the ASAC directed two aircraft in exercise 7 but only one in exercise 3. Rates on the other circuits were about the same in the two exercises except for information passed on the RT/2 intership circuit. Instructor grades may be negatively related to this increase on the RT/2 circuit, as discussed later.

Instructor grades were used as the criteria for evaluating communications measures. Percentage scores for teams and subteams are shown in Table 5. Instructor grades may be obtained from the percent scores by using the weights at the left of Table 5. The evaluator score counts 40 percent of the team grade. Since this weighting tends to obscure some of the differences between teams, it is important to look at both team and subteam scores in relating communications to performance. For example, on exercise 3, the ASACs were much more variable in performance from team to team than were the evaluators. This is indicated by the standard deviation of the unweighted percentage scores (8.0 for the evaluator and 18.7 for the ASAC). However, when the scores are weighted (40% and 15%) for assigning team grades, the standard deviation for evaluators is larger (3.2 vs. 2.8).

Table 4

Communication Rates in Exercises 3 and 7
(Number of Message Units Per Minute)

		1JS Command		61JS Sonar		R/T2 Ship to Ship		R/T3 Ship to Air	
Category	Ex.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Information	3	3.44	1.18	7.01	2.23	2.86	.74	2.76	.85
	7	3.56	1.36	7.30	2.40	3.47*	.84	4.11*	.94
Questions	3	1.11	.48	.34	.34	.14	.10	.21	.13
	7	.88	.56	.46	.53	.15	.12	.46*	.28
Responses	3	1.05	.49	.34	.44	.20	.15	.21	.15
	7	.88	.48	.41	.42	.12	.10	.52*	.45
Affirmations	3	.64	.41	.02	.06	.02	.04	.04	.10
	7	.57	.27	.00	.00	.02	.03	.12	.16
Evaluations	3	.60	.56	.07	.14	.16	.11	.08	.14
	7	.70	.62	.09	.18	.24	.14	.08	.09
Directions	3	1.91	.48	.08	.24	2.40	.83	1.07	.57
	7	1.84	.46	.06	.10	2.40	.77	2.53*	.48
Other	3	3.70	.79	.78	1.19	2.95	.60	2.22	.72
	7	3.34	1.03	.21	.30	3.28	.69	4.26*	.78

*p < .05.

Table 5

Percentage Scores on Exercise 3 and 7

	Exercise 3		Exercise 7	
Subteam	Mean	S.D.	Mean	S.D.
Evaluator (40,40)	72.2	8.0	76.8	11.5
ASAC (15,15)	67.3	18.7	67.3	16.4
TACCOM (15,15)	64.0	13.3	74.0*	12.3
CIC (15,10)	75.3	12.3	77.0	8.0
Sonar (10,10)	69.0	10.7	76.0*	8.3
UB Plot (5,10)	66.0	14.6	77.0*	14.0
Average	69.0	—	74.7	—
Team Grade (100)	70.0	—	74.9	—

Note. Numbers in parentheses are weights (%) used for grading in exercises 3 and 7 respectively.

*p < .05.

Mean percentage scores for the TACCOM, sonar, and UB plot were significantly better on exercise 7 than on exercise 3. This is probably a straightforward practice effect due to the fact that these groups performed essentially the same tasks on both exercises. In contrast, the ASACs faced a considerably more complex task on exercise 7, and their mean percentage score did not change.

The standard deviations in Table 5 suggest that most of the variation in team grades is attributable to variations in grades for the evaluator, ASAC, and TACCOM. A similar result is obtained if correlations are computed between team and subteam grades--see Table 6. Evaluator grades were most highly correlated with team scores. The ASAC and TACCOM scores were the only other scores that were consistently correlated with team grades on exercises 3 and 7. This is understandable since the CIC, sonar, and UB plot scores contributed at most 10 percent each to the team grade.

Table 6

Correlations Between Subteam Scores and Criterion Scores

	Subteam					
Criterion Score	Eval	ASAC	TACCOM	CIC	Sonar	UB Plot
<u>Team Total:</u>						
Exercise 3	.74**	.60*	.46*	.46*	.43	.05
Exercise 7	.89**	.74**	.44*	.24	.55*	.48*
<u>Evaluator:</u>						
Exercise 3	--	.18	.01	.46*	.20	-.09
Exercise 7	--	.46*	.30	.19	.50*	.26

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

There were very few significant correlations between subteam scores. There was a slight tendency for evaluator scores to be related to the scores of other team members but the relationship was not nearly as marked as in the preliminary study. The checklist measured performance at a finer level of detail and so may have been more sensitive to subteam dependencies.

Correlations were computed between instructor grades and communication rates to see if rates in the various communication categories were related to performance. Correlations were obtained separately for each of the four communication networks and are shown in Table 7. Overall, relatively few significant correlations were found. Most of the significant correlations occurred for the external ship-to-ship and ship-to-air circuits, and were concentrated most heavily in the communication categories of information, responses to questions, and evaluations.

The pattern of correlations changed noticeably from exercise 3 to exercise 7 for all circuits. On the R/T3 ship-to-air circuit, the correlations tended to shift from negative

Table 7

Correlations of Communication Rates with Team and Subteam Scores

Comm. Type	Exercise 3							Exercise 7						
	Team	Eval	ASAC	TACM	CIC	Sonar	UB Plot	Team	Eval	ASAC	TACM	CIC	Sonar	UB Plot
R/T2 Ship-to-Ship Circuit														
Inform	.35	.04	.15	.45	.18	.46*	-.08	-.58*	-.58*	-.11	-.48*	-.17	-.17	-.40
Question	.35	.55*	.42*	-.32	.06	-.06	-.30	.14	.07	.53*	-.28	.20	-.03	-.10
Respond	-.11	-.06	.29	-.52*	.17	-.53*	-.61*	.14	.02	.55*	-.12	.02	-.20	.05
Affirm	.30	-.47*	.06	.09	-.40	-.21	.20	.36	.24	.39	.42	.09	.44	-.25
Evaluate	-.12	-.22	-.11	.09	-.21	.14	.38	-.45*	-.47*	-.19	-.45*	-.09	-.04	-.23
Direct	.40	.07	.32	.46*	.12	.39	-.08	.00	-.08	.25	-.14	-.04	.11	-.05
Other	.31	.06	.28	.32	.13	.30	-.19	-.33	-.40	.28	-.53*	-.05	-.10	-.30
R/T3 Ship-to-Air Circuit														
Inform	-.17	-.55*	.44	.14	-.33	-.22	-.13	.65*	.49*	.78*	.32	-.18	.38	.24
Question	-.28	.19	-.61*	-.28	-.01	.03	.07	.32	.50*	-.13	.08	.01	.33	.13
Respond	-.29	.12	-.72*	-.10	.22	-.05	-.15	.32	.49*	-.16	.17	-.14	.40	.15
Affirm	.37	.19	.51*	-.08	.24	-.02	-.06	.30	.19	.40	.50*	-.21	.01	-.11
Evaluate	-.14	-.14	.46	-.54*	-.07	-.32	-.34	.34	.21	.47*	.10	-.30	.52*	.15
Direct	.37	.03	.18	.36	.34	.51*	-.09	-.33	-.19	-.23	-.12	.13	-.23	-.67*
Other	-.06	-.38	-.08	.34	.17	.27	-.16	.10	-.04	.46*	-.05	.12	.27	-.23
1JS Command Circuit														
Inform	-.03	-.02	-.04	-.06	.09	.17	-.22	-.37	.36	-.05	-.42	.13	-.22	-.27
Question	.11	-.09	.25	.19	-.28	.10	.35	-.13	-.22	.08	-.06	-.22	-.02	.07
Respond	.28	-.02	.54*	.18	-.10	.01	.23	-.05	-.13	.08	.00	-.19	.08	.08
Affirm	.24	.29	.18	-.17	.38	-.20	-.07	-.20	-.17	-.28	.10	-.60*	.24	-.05
Evaluate	.15	-.03	.45	-.17	-.23	.13	.41	.21	.25	.31	-.10	-.08	.13	-.04
Direct	.45	.39	.23	.28	.55*	-.27	.45	.02	-.15	.46*	-.05	-.37	.17	-.01
Other	.04	.02	-.08	.12	.19	-.17	.09	-.17	-.38	.07	-.02	.13	-.24	.22
61JS Sonar Circuit														
Inform	.19	.20	.00	.12	-.23	.55*	.28	.12	-.12	.24	.13	.11	.11	.38
Question	-.46	-.20	-.38	-.17	-.30	-.42	.12	-.09	.17	-.52*	.01	-.12	-.11	-.03
Respond	-.39	-.07	-.41	-.22	-.20	-.33	.17	-.22	-.04	-.47*	-.03	.03	-.40	-.06
Affirm	.10	-.07	.11	-.13	.37	.27	-.07	--	--	--	--	--	--	--
Evaluate	.37	-.13	.59*	.24	.37	.03	-.25	.15	.14	.01	.09	-.18	.49*	.10
Direct	.14	.25	-.28	.34	.07	-.05	.29	-.37	-.40	-.27	.05	.23	-.59*	-.18
Other	-.14	-.13	-.27	-.24	.34	.26	-.11	-.28	-.17	-.31	-.26	.34	-.45*	-.09

*$p < .05$.

to positive values but, on each of the other three circuits, the correlations tended to shift toward negative values; that is, positive correlations became smaller or negative and negative correlations became more so. These results suggest either that the instructors graded differently, that the better teams learned to reduce unnecessary communications, or both. Information on this point may be obtained by a more detailed examination of correlations on the external circuits, where the clearest trends occurred.

On the R/T2 intership circuit, no particular pattern was evident on exercise 3; however, on exercise 7, most of the correlations were negative. All of the correlations for the "voluntary" message categories of information and evaluations were negative and six of these correlations were significant. Discussion with instructors revealed that the reason for these negative relationships is that instructors downgrade unnecessary communications. Particular mention was made of the fact that weaker teams often overload the RT/2 net by making too many status reports to the task group commander. It may be noted that all of the significant negative correlations for subteams on trial 7 occurred for the TACCOM and evaluator, who together control the message traffic on this net.

On the R/T3 air control circuit, there was a mild tendency on exercise 3 for message rates to be negatively related to performance scores. This tendency was clearly reversed on exercise 7 where, except for directions, the great majority of the correlations were positive. Most of the significant correlations occurred for the ASAC and evaluator. On exercise 7, the ASAC and evaluator were responsible for controlling two aircraft rather than one, and this necessitated a great increase in RT/3 communications (see Table 4). These results, together with the results for the RT/2 circuit, are comparable to the findings of Briggs and Johnston (1966, 1967) that relationships between communication rates and team performance tend to be positive for essential communications and negative otherwise.

DISCUSSION

Some relationships were found between performance and communication rates on the external circuits, but these relationships were not consistent enough or strong enough to be very useful for assessing team performance. Other ways of measuring communications should be developed. The simplest and most economical way is by means of a checklist that includes quality and timeliness of communications. Measures of quality should cover correctness, completeness, and relevance of communications occurring in response to the key events in an exercise.

There does not appear to be any single sufficient measure of team output in surface ship ASW exercises. A better approach is to use a checklist that evaluates all the critical responses of team members and subteams in an exercise. The reason for this is that a single measure, such as weapon miss distance, reflects only a small part of the many important functions that a team should perform during an exercise. Localizing the submarine's position and getting the ship into position to shoot a weapon requires the efforts of many team members. A surface plot of the situation must be maintained, weapons and countermeasures must be readied, and sonar search procedures must be instituted. Prior to weapon use, approach and attack tactics must be worked out and implemented. Extensive coordination must be maintained between subteams and with other surface and air units. Proper safety procedures are essential when entering the torpedo danger area or when firing an ASROC in the vicinity of friendly aircraft and ships. The ship may lose sonar contact or the submarine may employ a decoy, and a suitable response must be planned and instituted. A second submarine may be detected close in and an emergency attack carried out where speed is more important than accuracy. Finally, usually late in the exercise, the ship may launch one or more deliberate attacks against the submarine it has been pursuing. Under these circumstances, miss distance is of minor usefulness for either measurement or feedback.

A useful checklist for evaluating team performance should have a number of characteristics:

1. It should be similar to the checklist in previous use in that it evaluates specific actions of subteams and members. This would be particularly useful for feedback to teams.

2. It should have a simplified tabulation and scoring method so that it can be completed during an exercise without interfering with other duties of instructors.

3. Unweighted percentage scores should be used for feedback to subteams and individuals. Weighted scores for qualification grading can be computed separately as appropriate.

4. The checklist should be based on a set of objectives that are sufficiently precise to allow specification of objective scoring criteria.

CONCLUSIONS

Quantitative measures of the volume of communications are of limited usefulness for assessing team and individual performance. Measures of quality and timeliness appear to be more appropriate, and should include ways of assessing incomplete, excessive, or late communications.

A multiple scoring system that evaluates team responses to the many significant events occurring in an ASW exercise is needed for team evaluation and feedback. For maximum accuracy and objectivity, the system should employ a checklist that can be completed during an exercise.

RECOMMENDATIONS

1. An objective performance checklist should be developed for use in 14A2 ASW training exercises and for grading Phase I qualification exercises. Particular attention should be given to assessing the timeliness and quality of communications. The checklist should incorporate the performance standards given in the ASW objectives[1] developed as part of this project (Slough & Stern, 1981; Stern & Slough, 1981).

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[1]Data taken from tapes of communications collected for this report were part of the information used to develop the objectives.

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