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COMPARISON OF PERFORMANCE ON ANALOGOUS SIMULATED AND ACTUAL TROUBLESHOOTING TASKS

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COMPARISON OF PERFORMANCE ON ANALOGOUS SIMULATED AND ACTUAL TROUBLESHOOTING TASKS

by

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BRIEF

This investigation compared the performance of a group of subjects assessed on a simulated troubleshooting task and on the identical actual troubleshooting task using real equipment. Subjects were 14 students in the experimental training program for Electronics Technicians, conducted by the Navy Training Research Laboratory, San Diego.

Analysis of results revealed that the simulated performance measure did not provide a valid estimate of performance proficiency on the actual task. Obtained negative inter-test correlations indicate that simulated test results would actually be misleading in terms of estimating actual performance scores. In addition to performance score discrepancies, there were observable differences in specific performance procedures and overall troubleshooting strategy attributable to the differences in test mode. The evidence strongly suggests caution in assuming that a simulated performance measure, even with considerable face validity, will provide a valid estimate of actual performance on a common task.

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COMPARISON OF PERFORMANCE ON ANALOGOUS SIMULATED AND ACTUAL TROUBLESHOOTING TASKS

A. Background

This exploratory investigation is a part of the larger research effort to develop and implement a practicable system for valid assessment of the performance skills required for job proficiency in Navy ratings. There is an expressed need in the Navy for methods of assessing proficiency on actual job performance tasks, since practical performance skills are often the most critical component of total job competence, yet they are presently least amenable to objective measurement. Intellectual aptitudes and knowledge requirements for any particular rating may be reasonably well measured by conventional paper and pencil tests, but valid measures of proficiency on the practical factors of the rating are not generally available. For ratings in which performance chiefly involves administrative and clerical duties, paper and pencil tests may constitute a reasonable job task sample. In technical ratings requiring complex practical job skills, such as troubleshooting in the electronics ratings, proficiency evaluation requires tests with broader measurement capability. Despite the enormous amount of effort which has been devoted to the problem of assessing troubleshooting proficiency, there remains a large number of relatively unsolved theoretical and practical assessment problems. Ideally a troubleshooting proficiency test for Navy-wide use should be portable, brief, inexpensive, simple to administer and score, and yet yield a valid estimate of actual troubleshooting ability on the job. Unfortunately, currently available tests lack some or most of these desirable features. One of the alternative approaches to performance testing has been an attempt to develop simulated tests which, by substitution, can reduce some of the time, cost, and technical requirements of actual performance tests. The true value of such simulated tests, of course, depends upon the extent to which they can provide valid proficiency estimates of the actual performance task being measured.

The present study, accordingly, is concerned with evaluative comparisons of the results obtained from assessment of troubleshooting proficiency using a simulated performance task and using the analogous actual troubleshooting performance task. Such experimental comparisons provide information prerequisite to development and implementation of improved performance evaluation systems.

B. Experimental Procedures

Two highly analogous tasks, one presenting a troubleshooting problem in simulated form and the other being the actual troubleshooting performance task, were utilized as a basis for performance comparisons. The investigation was more concerned with determining

the similarities and differences of task performance under the two assessment modes than in simply establishing the score validities of the simulated task. For this purpose the development of an identical test problem was essential in order to permit step by step comparison of the troubleshooting approach, logic and sequence. Individual performance on each version of the task could then be contrasted in terms of specific performance characteristics, and in terms of correlational comparisons of derived performance scores.

1. The Tasks

a. Simulated. The troubleshooting Electronics-Trainers for the Superheterodyne Receiver (Van Valkenburgh, Nooger and Neville, Inc. NAVPERS 92088-5B) was used as the vehicle for the simulated performance task. An alternate form of the same series (NAVPERS 92088-9B) served as a practice vehicle in order to assure that subjects had recent familiarity with the procedures of the simulated task. These instruments are among the most commonly found simulated training and testing devices used in Navy technical training courses. The two forms utilize the same procedural format but differ with regard to the specific superheterodyne casualty which is the basis of the test problem. The casualty problem of the first form is identical to that used for the actual performance task, and involves a faulty resistor (R-11) which produces only a low hum as the loudspeaker output. The practice form casualty involved a faulty tube (V-6) which resulted in no loudspeaker output. These troubleshooting tests present a verbal description of the problem casualty symptoms which the examinee is expected to correct by a series of simulated troubleshooting steps. To perform each of these steps, the examinee successively selects appropriate test point checks, measurements, or parts replacement alternatives from among the many possible choices listed on the Trainer-Tester sheet. For each selected troubleshooting step, the examinee must erase the silver covering material which obscures the information given for each item. This information consists of a resistance, voltage, or output signal reading, or the result of making a specific parts replacement. The examinee attempts to solve the problem by erasing as few items as possible until he locates the item which yields "TC" (trouble corrected) to indicate that he has repaired the casualty. A detailed schematic diagram of the equipment is provided as an accompanying task aid to the testee.

b. Actual. The actual troubleshooting performance task was the real equipment replication of the troubleshooting task presented in the simulated version. Superheterodyne radio receivers were constructed directly from the detailed schematic diagram of the simulated task. The identical component casualty (R-11) of the simulated task was then inserted into these vehicles to provide an actual duplication of the simulated test vehicle and problem. Examinees were required to isolate and repair this casualty using

symptom information and a detailed schematic diagram identical to that of the simulated task.

2. The Sample

Subjects for this investigation were 14 students in the experimental training program for Electronics Technicians, conducted by the Navy Training Research Laboratory, San Diego, 1964 - 1966. All subjects had completed the Fundamentals phase of the course and about 17 weeks of the advanced Equipment phase (Radar or Communications) at the time of the first testing session.

3. Assessment Procedures

The simulated and actual performance tests were administered to the trainees in counterbalanced order with approximately three weeks interval between the first and second testing. One half of the subjects were given the simulated tasks first while the remainder of the subjects were initially given the actual performance task. The performance version of the test was given individually in a room separate from where the simulated form was administered. One observer monitored the simulated test administration to ascertain that test procedures were correctly followed by all examinees. One technical observer was used for each examinee in administering and recording performnace on the actual superheterodyne task. Observers were former Navy technicians with considerable recent experience in developing and grading performance tests.

Although the simulated test format was generally familiar to students in the experimental training course, one form (9B) was administered first to provide immediate practice and to obscure the relationship between the common simulated and actual test casualty. None of the subjects apparently perceived the similarity of the casualty used in the two test versions, separated by a three-week interval. This lack of recognition may be ascribed to several favorable factors in the experimental situation. The experimental tests were administered by the same technical personnel who administered regular within-course and final examinations for the training course. Additionally, the experimental tests were intermixed with regular course testings, and were of such similar nature as to be indistinguishable from them, since simulated and actual troubleshooting performance constituted a large portion of the course work.

4. Test Scoring

Grading of performance tests is typically a difficult and uncertain task, and the present measurements were no exception. There is no specified method for objectively scoring the Van Valkenburgh forms, and the actual superheterodyne performance

test was amenable to scoring only to the extent that any complex performance task involving real equipment and casualties may be. The scoring procedures employed in the present investigation were determined, to a great extent, by experience from considerable previous research work with both these types of tests. An effort was made to score the most objective factors yielded by the Van Valkenburgh forms, and to score similar aspects on the actual troubleshooting test to provide a basis for meaningful performance comparisons. To this end, a scoring sheet was developed for the actual task which paralleled the listing and identification of components and check points given in the simulated version. It was expected that although any individual's absolute scores on the simulated task might be considerably different from those on the actual task, his relative performance might be constant enough to yield consistent performance score rankings for subjects across tests.

Six relatively objective scores were obtained from performance on each version of the test: (1) Number of Steps, (2) Correct Steps, (3) Incorrect Steps, (4) Total Time, (5) Tester's Rating, (6) Parts Replaced. Certain test administration procedures were necessary to provide this scoring information. In the simulated test, examinees were instructed to number each step (erasure to disclose item information) in sequence from their first "1" to their final item. In the actual test, the monitor recorded, in order, each troubleshooting step the examinee made. These recorded step sequences were later transposed to the scoring sheet paralleling that of the simulated form.

In addition to noting the simple step sequence (e.g. signal inject at V2-8), monitors in the actual testing were able to record detailed descriptions of the procedures employed by the examinee in performing each step. Thus a record was made not only of what was done, but how it was accomplished (e.g. power level, frequency, and procedural facility employed in injecting the signal at V2-8). No such relevant performance characteristics were available from the simulated test forms since it is explicitly assumed in that version that "...all checks and measurements are made with the proper instruments, correctly used and interpreted." For both simulated and actual tests a stopwatch record was maintained of the total elapsed time for the troubleshooting performance of each examinee, and ten minute intervals were indicated throughout the testing.

The score for Number of Steps, therefore, was simply the total number of checks, measurements, or part replacements recorded on the scoring sheets for both simulated and actual tests. The Number of Correct Steps was derived from this total, and required the technical judgements of the test observers after viewing the total recorded test performance. "Correct" steps were those which were judged, within the total approach followed by the individual testee, to be logical alternative troubleshooting checks which would yield

information relevant to locating the casualty. "Incorrect" steps were those judged to be illogical, redundant, or otherwise not reasonable alternative steps toward casualty isolation. Despite the subjective element of these two scores, it was found that the technical judges were able to make reliable and congruent decisions based on the relation of individual steps to total test sequence. This scoring method allows equal credit for any of a number of minor variations in the troubleshooting sequence, since the correctness of each step depends upon how well it fits into the total approach uniquely employed by each individual.

The score for Total Time was simply the number of minutes required by each examinee to finish the simulated and the actual task. Variations in troubleshooting progress for each subject within the recorded ten minute intervals did not yield any discriminating grading information and was therefore not included in the final score analyses.

The Tester's Rating comprised the overall proficiency grade assigned by the technical observer. This score is more meaningfully applicable to the actual performance test where a number of relevant observable troubleshooting skills (use of test equipment, safety procedures, etc.) may give a more comprehensive indication of overall performance proficiency. The Tester's Rating score was assigned on the basis of a five point scale which incorporates descriptive statements of the typical performance characteristics exemplifying each of the proficiency levels from 1 "inadequate" to 5 "excellent."

The score for Parts Replaced was the total number of items erased in this category on the simulated test. Incorrect parts replacement items, when erased, yielded the information "SR" (Symptom remains) indicating that further steps were required. For the actual performance test this score was similarly the number of components which were replaced in an attempt to repair the casualty.

C. Results and Discussion

The results of this experimental comparison of simulated and actual tasks are primarily intended as an analysis of performance characteristics evoked by different test modes rather than as a statistical assessment of the psychometric properties of the test instruments. The relatively small sample size and the absence of unitary test scores of confirmed reliability preclude the presentation of test results in terms of total or part-test score validities. In order to maximize the number of meaningful performance comparisons, however, inter-test correlations were obtained for five of the six scored performance variables. (The range of scores for Parts Replaced in the actual test was too limited for meaningful correlational analyses.) Certain other, less statistically

specifiable performance results are also included as relevant to the general problem of proficiency measurement.

1. Test Scores

A comparison of the scores obtained on the simulated and on the actual performance tests, in terms of range and average, is presented in Table 1. The simulated practice test results are included in this and subsequent tables.

TABLE 1

Mean and Range of Scores on Simulated and Actual Tasks (N=14)

Scores		Tests		
		Actual	Simulated	Simulated (Practice)
No. of Steps	L	7	6	6
	H	31	38	31
	$\bar{X}$	13.9	17.6	14.6
Correct Steps	L	5	5	3
	H	15	21	15
	$\bar{X}$	8.6	9.9	7.5
Incorrect Steps	L	0	1	0
	H	25	32	24
	$\bar{X}$	5.3	7.7	7.1
Total Time	L	10	5	5
	H	70	32	43
	$\bar{X}$	29.1	18.6	19.6
Tester's Rating	L	1	1	1
	H	4	4	5
	$\bar{X}$	3.1	2.9	2.8
Parts Replaced	L	1	1	1
	H	2	8	5
	$\bar{X}$	1.6	3.1	2.3

The comparisons of Table 1 indicate a fair degree of similarity between performance scores on the two simulated tests, with the

practice form requiring slightly greater average time for completion, possibly as a result of order of administration. As expected, the actual performance test required considerably more time to complete, on the average, than either simulated test. The most notable difference apparent from the table is the discrepancy between simulated and actual tasks in the number of parts replaced. No examinee replaced more than two parts in the actual task. (One replacement was necessary to repair the casualty). In the simulated version, however, as many as eight parts were replaced. It is evident that this difference was largely due to the fact that parts replacement in the simulated task required only a simple erasure, whereas in the actual task considerably more effort was involved. This consideration probably affected all actual performance steps (checks and measurements) as indicated by the slightly lower average number of total steps for the actual test sequences.

2. Inter-test Correlations

The rank order inter-test correlations for the five scored performance variables are presented in Table 2.

TABLE 2

Rank Order Inter-test Correlations for Five Performance Variables (N=14)

	Tests		
Test Score	Simulated x Actual	Simulated (Practice) x Actual	Simulated x Simulated (Practice)
No. of Steps	-.32	.40	-.12
No. of Correct Steps	.14	.69	-.10
No. of Incorrect Steps	-.19	-.07	-.13
Total Time	-.50	.30	-.26
Tester's Rating	-.35	-.06	-.16

The correlational comparisons of Table 2 reveal a number of striking features concerning the relationship between the performance variables on the simulated and on the actual tasks.

A predominant feature is the lack of positive relationship between performance scores on the simulated test and scores on the actual task which involved an identical troubleshooting problem and associated job aids. Indeed, four of the five scored variables are negatively related, with the highest of these (-.55) based upon the objectively determined Total Time.

A secondary consideration is the fact that the scores on the two simulated tests, the first administered for practice purposes, bear no relationship to each other despite the virtual equivalence of the two tasks in all aspects except the specific problem casualty. Again, the comparison of Total Time yielded the poorest coefficient for positive prediction (-.26).

Tester's Rating, which was designed to provide the best overall summary of task proficiency, is negatively correlated for all three inter-test comparisons.

The highest inter-test correlation involves Number of Correct Steps on the actual test and on the simulated test used for practice. Since this simulated test involved a different casualty from the actual test, and since scores for Number of Incorrect Steps, and Tester's Rating are both uncorrelated, it is difficult to view this single coefficient as representing a realistic relationship of practical predictive utility.

No other individual coefficients in this table command attention. It may, in fact, be noted that of the fifteen inter-test comparisons, only four yielded positive correlations. Three of these four involve comparisons between the practice test and the actual performance test, where meaningful relationships would logically be least expected.

3. Test Evaluation

In view of the lack of relationship between simulated and actual performance variables, a subsidiary attempt was made to estimate the practical validity of the tests involved, in terms of an outside measure of actual troubleshooting performance. For this purpose, correlations were computed between Tester's Ratings and the performance achievement scores of examinees for the Equipment phase of the experimental training course. This performance achievement score was based on a total of approximately thirty performance tests taken during, and at the end of the training course. Table 3 presents the resultant rank order coefficients. These obtained correlations tend to support the assumption that the actual superheterodyne test, developed for this study, is a better job sample of real performance tasks than are the simulated performance tasks.

TABLE 3

Rank Order Correlation of Tester's Ratings
With X-ET Course Performance Grade

Test	Rho
Actual Performance	.55
Simulated Performance	-.36
Simulated Performance (Practice)	.00

4. Performance Characteristics

There are a number of important non-statistical comparisons between the simulated and actual performance, which involve aspects other than the six scored variables. These performance comparisons are based largely on the test observations and interview information provided by the technical monitors. From these comparisons it is apparent that there were many differences in task approach, strategy, and technique which were directly associated with the test medium. These performance differences probably contribute to the negative correlations obtained between simulated and actual scores.

In the simulated performance situation all checks and measurements are obtained by simple erasure, and results given are invariably accurate. In actual performance, checks and measurements require considerably more effort, and the accuracy of the readings depends upon how correctly the test equipment is used. Thus, in taking the actual performance test, examinees often repeated the same check or measure because they were not sure of the accuracy of their findings. Test protocols show as many as eight similar checks made by testees at a single test point (e.g. plate of V-2), even though a single correct check would be sufficient to provide all available information at that point. Dubious measurements tended to affect the entire troubleshooting sequence. Reliance upon an incorrect reading, for example, could lead examinees to a false casualty assumption. Conversely, uncertainty over a correct reading sometimes caused students to persist in repeating an unproductive line of troubleshooting strategy.

There were also substantial differences in the number of parts replaced under the two test situations, as previously noted. In the actual task, students were reluctant to unsolder or disconnect

components from the chassis, but in the simulated task, where parts replacement required virtually no effort, students too often resorted to parts replacement in an effort to solve the problem.

The test format also affected overall troubleshooting strategy to some extent, as indicated by detailed comparison of the procedural sequences used by the same testee on the simulated and on the actual task. Only one of the fourteen testees even made the same initial troubleshooting check on both his actual and simulated test.

In the actual performance task students frequently made basic errors in test equipment usage, logic, and safety procedures, which were not revealed by the simulated task. Examples of commonly observed errors include: touching high voltage points when taking B+ measurements, injecting IF into the antenna, taking resistance readings with the power on, setting signal generator input levels too low, neglecting to zero meters, improper setting of tube tester controls.

D. Summary and Conclusions

The critical need for performance proficiency measures has engendered the hope that simulated performance tests may be employed to provide reasonably valid estimates of actual performance ability. This investigation provided an opportunity to compare the performance of subjects on carefully devised simulated and actual troubleshooting performance tasks involving identical casualties and job aids.

The summary results of this experimental comparison follow:

(1) There were no significant positive correlations between the simulated performance test and the actual performance test on any of the five scored performance variables. Four of the five inter-test score comparisons, in fact, yielded negative correlations.

(2) There were observable differences in specific performance procedures and in overall troubleshooting strategy attributable to the differences in test mode.

(3) Many of the troubleshooting "enabling" skills which seriously affect performance in the actual task situation were not measurable in the simulated task situation.

(4) There were no positive correlations between the performance scores of the two simulated tasks, one of which was administered for practice purposes.

(5) The actual performance test developed for this investigation had considerable face validity as a job sample of troubleshooting tasks, and was found to correlate significantly with an

outside performance criterion. Neither of the simulated tasks correlated positively with this performance criterion.

In summary, the simulated performance measure employed in this investigation did not provide a valid estimate of proficiency on the identical problem requiring actual performance. Negative inter-test correlations indicate that simulated test scores would actually be misleading in terms of estimating actual performance scores.

The restricted generality of the present study does not admit the conclusion that simulated tests are necessarily without value. Other experimental contexts might yield more positive results, and simulated performance tasks may serve an educative and practice function in training apart from the assessment role. Improvement of the simulated test by modification of the test directions, the scoring methods, and the task procedures, might make the simulated measure a more realistic approximation of the actual performance task. The evidence does, however, strongly suggest caution in assuming that any simulated performance measure, even when it possess considerable common identity to the actual task, can provide a valid estimate of actual performance proficiency. In the development of Navy-wide systems for proficiency evaluation, simulated performance measures should be empirically validated against real performance criteria, before they are accepted for incorporation into the total assessment system.

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13. ABSTRACT

This investigation compared the performance of a group of subjects assessed on a simulated troubleshooting task and on the identical actual troubleshooting task using real equipment. Subjects were 14 students in the experimental training program for Electronics Technicians, conducted by the Navy Training Research Laboratory, San Diego. (U)

Analysis of results revealed that the simulated performance measure did not provide a valid estimate of performance proficiency on the actual task. Obtained negative inter-test correlations indicate that simulated test results would actually be misleading in terms of estimating actual performance scores. In addition to performance score discrepencies, there were observable differences in specific performance procedures and overall troubleshooting strategy attributable to the differences in test mode. The evidence strongly suggests caution in assuming that a simulated performance measure, even with considerable face validity, will provide a valid estimate of actual performance on a common task. (U)

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