Research Note 85-39

20000801172

AD-A160 709

A CORRELATIONAL ANALYSIS OF THE PRELIMINARY MACS M16A1 EVALUATION: A REDIRECTION FOR MACS TRAINING SOFTWARE

James E. Schroeder

for

ARI Field Unit at Fort Benning, Georgia
Seward Smith, Chief

TRAINING RESEARCH LABORATORY
Harold F. O'Neil, Jr., Director

U. S. Army
Research Institute for the Behavioral and Social Sciences

September 1985

U. S. ARMY RESEARCH INSTITUTE
FOR THE BEHAVIORAL AND SOCIAL SCIENCES

A Field Operating Agency under the Jurisdiction of the

Deputy Chief of Staff for Personnel

EDGAR M. JOHNSON
Technical Director

WM. DARRYL HENDERSON
COL, IN
Commanding

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER Research Note 85-89	2. GOVT ACCESSION NO. AD-A160709	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) A CORRELATIONAL ANALYSIS OF THE PRELIMINARY MACS M16A1 EVALUATION: A REDIRECTION FOR MACS TRAINING SOFTWARE		5. TYPE OF REPORT & PERIOD COVERED Jan. 1984-March 1985
		6. PERFORMING ORG. REPORT NUMBER --
7. AUTHOR(s) James E. Schroeder		8. CONTRACT OR GRANT NUMBER(s) --
9. PERFORMING ORGANIZATION NAME AND ADDRESS ARI Field Unit at Fort Benning, Georgia P.O. Box 2086 Fort Benning, GA 31905-0686		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 2Q263743A794
11. CONTROLLING OFFICE NAME AND ADDRESS US Army Research Institute for the Behavioral and Social Sciences, 5001 Eisenhower Avenue, Alexandria, VA 22333-5600		12. REPORT DATE September 1985
		13. NUMBER OF PAGES 16
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office) --		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

--

18. SUPPLEMENTARY NOTES

--

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

M16A1 rifle
Marksmanship
simulator
trainer

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

In the first preliminary evaluation of the Multipurpose Arcade Combat Simulator (MACS), positive transfer was indicated for the M203 grenade launcher and the M72A2 light antitank weapon. However, there was no appreciable positive transfer to a live-fire task for subjects receiving concurrent training on the M16A1 rifle MACS programs. The purpose of the present effort was to provide a more molecular analysis of the data collected in that evaluation in order to identify promising new directions for development of the MACS system. Another purpose was to estimate the reliability and external

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered) validity of the current MACS training programs. In general, the correlational approach indicated low MACS reliability (correlations of MACS scores with MACS scores), low MACS external validity (correlations of MACS performance with live-fire performance), and generally acceptable live-fire reliability (correlations of live-fire measures with live-fire measures). The most significant finding was that MACS measures of variability of light-pen readings (a measure of how steady the weapon was held) showed highly significant reliability and generally acceptable external validity. This was in sharp contrast to the MACS point-of-aim scores. Two hypotheses are proposed for future MACS development: that the MACS software be changed in a way that slight movements of the weapon during trigger manipulation be included in the determination of the MACS point-of-aim scores; and, that measures of variability be exploited in the MACS software in order to provide prediction of marksmanship performance, feedback for training marksmanship, and diagnosis and remediation of marksmanship problems.

TABLE OF CONTENTS

INTRODUCTION

The Multipurpose Arcade Combat Simulator (MACS) is a low cost, part-task simulator/trainer being developed by the US Army Research Institute's Fort Benning Field Unit. Using off-the-shelf components, MACS provides the shooter with valuable training feedback about location of bullet strike at various ranges, effects of wind and gravity, etc. The key component in MACS is a specially designed light pen which can be removed from one weapon system (e.g., the M16A1 rifle) and attached to another weapon system (e.g., the M203 grenade launcher or M72A2 light antitank weapon). Hence, MACS is a trainer which can train a variety of tasks on a variety of weapon systems (see Figure 1). For a more detailed description of MACS, see Schroeder (1983a).

Recently, preliminary experimental evaluations of the MACS M16A1 rifle, M203 grenade launcher, and M72A2 light antitank weapon were conducted (see Perkins, Selby, Broom, & Osborne, 1984). The results of these evaluations showed positive transfer to live fire for the grenade launcher and LAW, but minimal transfer for the MACS rifle application. Although there were some problems encountered in the field evaluation (see Perkins et al. for details), the lack of significant positive transfer was surprising given the extensive concurrent training provided on MACS. The Perkins et al. report concentrated on the experimental results. However, there was little correlational analysis discussed and such analyses could prove useful in discovering new directions, corrections, and software improvements for MACS. The purpose of this report is to provide additional correlational analyses in an attempt to identify promising new avenues of research and development for the MACS system.

PROCEDURE

In general, the experimental approach of Perkins et al. was to provide concurrent training on MACS for one platoon (experimental group) and no MACS concurrent training for a second platoon (control group). The subsequent analyses focused on comparisons between live-fire scores for the two groups. The correlational analyses in the present paper concentrate on the experimental group only because a vast amount of MACS performance data was collected on those subjects. Figure 2 (from Perkins et al.) shows the various Basic Rifle Marksmanship (BRM) periods of instruction and corresponding MACS training programs which were presented to the experimental subjects during concurrent training for those live-fire periods (see Perkins et al. for descriptions of the training in each of the BRM and MACS programs).

The following results and discussion sections will cover three different topics: the correlations of MACS measures with other MACS measures, the correlations of live-fire measures with other live-fire measures, and the correlations of MACS measures with live-fire measures. By analyzing the correlations of MACS measures with other MACS measures, the reliability of MACS can be assessed. Similarly, by addressing the correlations of live-fire measures with other live-fire measures, the correlational "ceiling" can be identified (i.e., how can a simulator predict live fire better than an identical

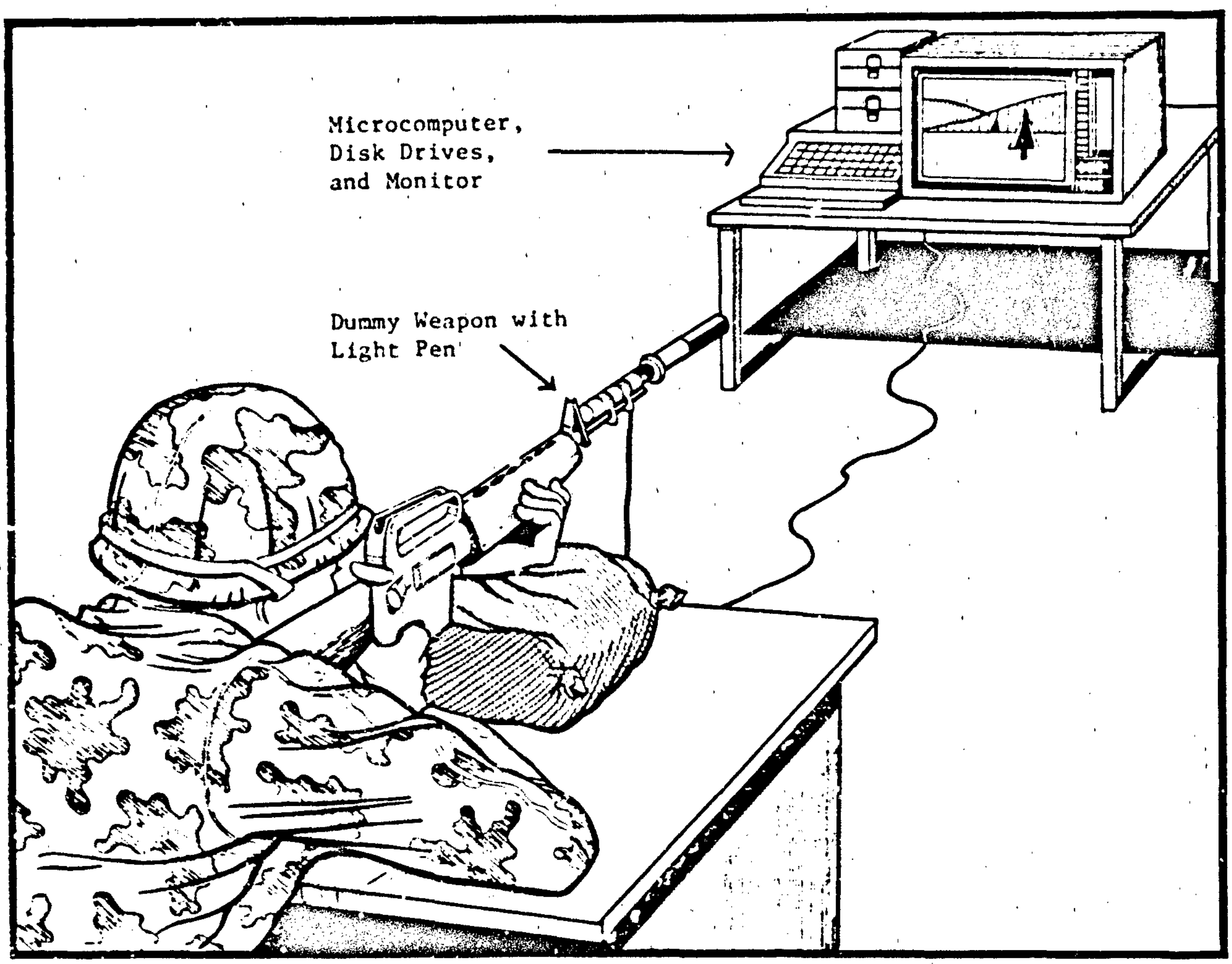

FIGURE 1. Figure 1 shows the hardware configuration for the MACS simulator/trainer for the M16A1 Rifle.

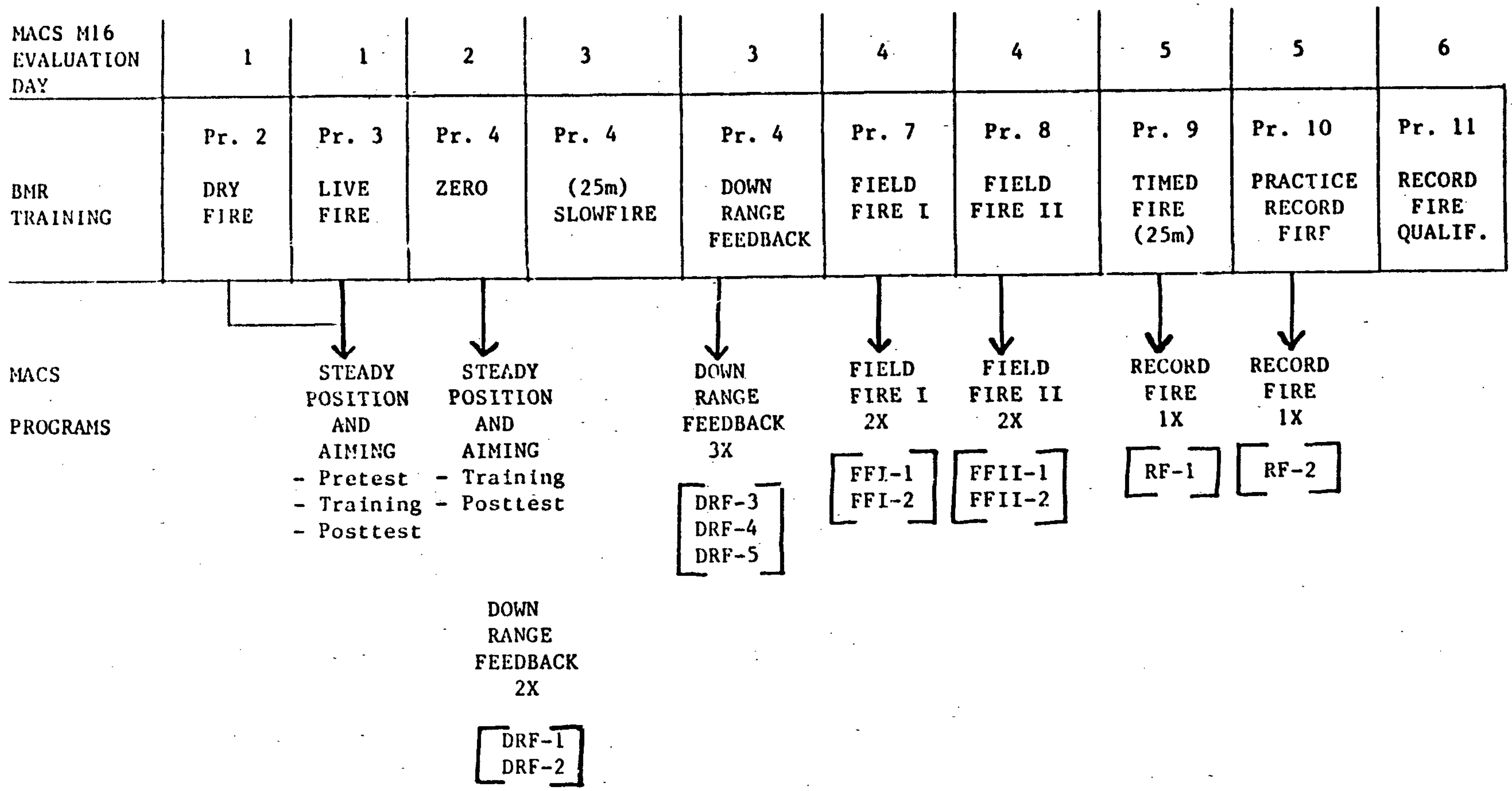

FIGURE 2. BRM training periods and corresponding MACS training programs presented during concurrent training.

live-fire task). By analyzing the correlations of MACS with live fire, the strengths and weaknesses of MACS can be identified. More specifically, in the development of a simulator/trainer, the first goal should be to identify simulator measures which correlate with the measures that the simulator is trying to train (i.e., live-fire marksmanship scores in this case). The correlational approach provided in the present paper provides a development aid by identifying the MACS variables with the highest potential. Once promising simulator measures/programs are identified, then efforts can be concentrated to improve those measures while less promising measures/programs can be discarded.

RESULTS

The Correlation of MACS Measures with MACS Measures

For the purpose of this analysis, nine independent measures of MACS performance were included from all stages of MACS training (see Figure 2). A list of these nine measures along with a brief explanation of each is presented in Table 1. Table 2 shows the resulting correlation matrix. There are three general classes of measurement shown in Table 2: the amount of time it took soldiers to fire at targets in the early pretest and posttest (Pretest Latency and Posttest Latency); the variability of weapon point-of-aim prior to firing (Pretest Steady Position and Posttest Steady Position); and accuracy scores (Down-Range Feedback, Field Fire I, Field Fire II, and Record Fire). The latency measures did not correlate significantly with each other indicating very low reliability. In addition, the latency measures did not correlate significantly with the other measures with the exception of a significant correlation between Pretest Latency with Field Fire II scores ($p < .05$). There was high test-retest reliability for the two variability scores ($p < .001$), but low correlations between those steady position scores and other MACS measures (except for the significant correlation between Posttest Steady Position and Field Fire II scores ($p < .05$). Finally, there were no significant correlations among the various accuracy measures with the exception of Field Fire II and MACS Record Fire ($p < .01$).

In summary, the correlational analysis indicated a general lack of reliability among the three general classes of MACS measures. In addition, only the variability measures (Steady Position scores) showed significant within-class reliability.

The Correlations of Live-Fire Measures with Live-Fire Measures

Table 3 provides a list of the various live-fire measurements included in the current analysis. One measure was included from each period of instruction from Period 4 to Period 10 and two measures were included for Period 11 (Combat Fire and Record Fire). All measures used were obtained directly from standard company performance records except Shot-Group Size from Period 6. Shot-Group Size from Period 6 was calculated from actual target measurements and represents the mean radial distance from the center of the shot group to the various shot locations. Table 4 shows the correlation matrix within the various live-fire measures. The Record Fire score correlated significantly with all other measures except Number of Rounds to Zero in Period 4. The lack of correlation

Table 1

MACS Variables and Descriptions

Variable	Description
Pretest Latency	Median time to fire the weapon in MACS Aiming pretest.
Posttest Latency	Median time to fire the weapon in MACS Aiming posttest.
Pretest Steady Position	Mean sum of standard deviations for X and Y for 5 light-pen readings before 6 shots in MACS Aiming pretest.
Posttest Steady Position	Mean sum of standard deviations for X and Y for 5 light-pen readings before 6 shots in MACS Aiming posttest.
Down-Range Feedback	Mean median score on 5 exposures to MACS Down-Range Feedback program.
Field Fire I	Mean median score on 2 exposures to MACS Field Fire I program.
Field Fire II	Mean median score on 2 exposures to MACS Field Fire II program.
MACS Record Fire	Mean median score on 2 exposures to MACS Record Fire program.

TABLE 2

Correlation Matrix: MACS With MACS

	POSTTEST LATENCY	PRETEST STEADY POSITION	POSTTEST STEADY POSITION	DOWN-RANGE FEEDBACK	FIELD FIRE I	FIELD FIRE II	MACS RECORD FIRE
PRETEST LATENCY	0.3179 (25) P=0.121	0.1110 (26) P=0.589	0.1327 (25) P=0.527	0.0951 (26) P=0.644	-0.1606 (26) P=0.433	0.400[illegible]* (26) P=0.043	-0.1263 (25) P=0.5[illegible]7
POSTTEST LATENCY		0.3414 (25) P=0.095	0.1388 (25) P=0.508	0.2968 (25) P=0.150	0.1218 (25) P=0.562	0.0286 (25) P=0.892	0.0670 (24) P=0.756
PRETEST STEADY POSITION			0.7670*** (25) P=0.000	0.1046 (26) P=0.611	0.0487 (26) P=0.813	0.1250 (26) P=0.543	0.2062 (25) P=0.323
POSTTEST STEADY POSITION				-0.2761 (25) P=0.182	0.0835 (25) P=0.691	0.4217* (25) P=0.036	0.2235 (24) P=0.294
DOWN-RANGE FEEDBACK					0.2221 (26) P=0.275	-0.1423 (26) P=0.483	0.1567 (25) P=0.45[illegible]
FIELD FIRE I						-0.1735 (26) P=0.397	0.5397*** (25) P=0.005
FIELD FIRE II							-0.0276 (25) P=0.896

* Indicates $P < .05$
** Indicates $P < .01$
*** Indicates $P < .001$

Table 3

Live-Fire Variables and Descriptions

Variable	Description
Rounds to Zero, Period 4	Number of rounds to zero in Period 4.
Hits in Period 5	Number of hits on scaled silhouette targets in Period 5.
Shot-Group Size, Period 6	Mean radial error from shot-group center on the 75 m target in Period 6.
Hits in Period 7	Number of hits on field-fire killable targets in Period 7.
Hits in Period 8	Number of hits on field-fire killable targets in Period 8.
Hits in Period 9	Number of hits on timed-fire scaled silhouette targets in Period 9.
Practice Record Fire	Number of hits in Practice Record Fire (Period 10).
Combat Fire	Number of hits in Combat Fire (Period 11a).
Record Fire	Number of hits in Qualification Record Fire (Period 11b).

TABLE 4

Correlation Matrix: Live Fire With Live Fire

	HITS IN PERIOD 5	SHOT-GROUP SIZE PERIOD 6	HITS IN PERIOD 7	HITS IN PERIOD 3	HITS IN PERIOD 9	PRACTICE RECORD FIRE	COMBAT FIRE	RECORD FIRE
ROUNDS TO ZERO PERIOD 4	-0.0194 (24) P=0.928	0.2088 (25) P=0.316	-0.1531 (25) P=0.465	-0.1962 (25) P=0.347	-0.4354* (21) P=0.049	-0.4590* (24) P=0.024	-0.2440 (25) P=0.240	-0.2513 (25) P=0.226
HITS IN PERIOD 5		-0.1996 (25) P=0.339	0.2410 (25) P=0.246	0.2334 (25) P=0.262	0.2531 (21) P=0.268	0.3750 (24) P=0.071	0.1331 (25) P=0.526	0.4476* (25) P=0.025
SHOT-GROUP SIZE PERIOD 6			-0.4011* (26) P=0.042	-0.2659 (26) P=0.189	-0.1671 (22) P=0.457	-0.6285*** (25) P=0.001	-0.2813 (26) P=0.164	-0.6868*** (26) P=0.000
HITS IN PERIOD 7				0.4331* (26) P=0.027	0.3787 (22) P=0.082	0.4115* (25) P=0.041	0.4603* (26) P=0.018	0.4212* (26) P=0.032
HITS IN PERIOD 8					0.2579 (22) P=0.246	0.2933 (25) P=0.155	0.3228 (26) P=0.108	0.4205* (26) P=0.032
HITS IN PERIOD 9						0.4419 (22) P=0.039	0.2092 (22) P=0.350	0.4338* (22) P=0.043
PRACTICE RECORD FIRE							0.3828 (25) P=0.059	0.7368*** (25) P=0.000
COMBAT FIRE								0.5396** (26) P=0.004

* Indicates P < .05
** Indicates P < .01
*** Indicates P < .001

between Period 4 scores and Record Fire scores is not surprising given the amount of time that elapsed between the two measurements and the large number of uncontrollable variables which can influence the Period 4 measure (e.g., lack of familiarity with the weapon, bad initial sight settings which throw rounds completely off the paper, etc.). According to the present results, the best single predictor of Record Fire score was Practice Record Fire followed by Shot-Group Size in Period 6, Combat Fire, and then a cluster of measures which correlated about the same (Hits in Period 5, Hits in Period 9, Hits in Period 7, and Hits in Period 8). In terms of magnitude of correlation coefficient, the best single early predictor of Record Fire was Shot-Group Size in Period 6. However, since Hits in Period 5 can be obtained a day earlier and with less difficulty, it may be the most functional early predictor of Record Fire scores.

In conclusion, the inter-correlations of various live-fire scores was generally high. Although there were not consistently significant correlations among the various periods of instruction leading to record fire, there were statistically significant correlations between all live-fire periods and record fire except for the number of rounds to zero in period 4.

The Correlations of MACS measures with Live-Fire Measures

Table 5 shows the correlations between the various MACS measures and the various live-fire measures. There was a general lack of correlation between the various MACS scores and live-fire scores. With the exception of a significant correlation between the MACS Field Fire 1 scores and the Shot-Group Size in Period 6, the only significant correlations involved the MACS measures of variability (Posttest Steady Position with Rounds to Zero in Period 4, Pretest Steady Position with Hits in Period 7, Posttest Steady Position with Hits in Period 7, Pretest Steady Position with Practice Record Fire, Posttest Steady Position with Practice Record Fire, and Posttest Steady Position with Record Fire).

In conclusion, the correlations among MACS scores and live-fire scores were generally low. The exceptions were the two MACS measure of variability of light-pen readings (measuring how steady the weapon was held just prior to shooting). In those two measures (Pretest Steady Position and Posttest Steady Position), 6 of 18 correlations were statistically significant.

DISCUSSION

In general, the MACS system was found to be low in reliability (as measured by correlations of MACS measures with other MACS measures) and low in external validity (as measured by correlations of MACS measures with live-fire measures). In comparison, there were generally acceptable correlations among the various live-fire measures.

On the surface, these results seem to indicate that not only can't MACS train marksmanship skills (i.e., Perkins et al.) but in addition, MACS can't predict live-fire performance. However, there was one potentially interesting trend in the present data. More specifically, the high reliability shown in the variability measures (as opposed to point-of-aim measures) and the external validity shown in the significant correlations of those variability measures

TABLE 5

Correlation Matrix: MACS With Live Fire

	PRETEST LATENCY	POSTTEST LATENCY	PRETEST STEADY POSITION	POSTTEST STEADY POSITION	DOWN-RANGE FEEDBACK	FIELD FIRE I	FIELD FIRE II	MACS RECORD FIRE
ROUNDS TO ZERO PERIOD 4	0.0545 (25) P=0.796	-0.0995 (24) P=0.644	0.2000 (25) P=0.338	0.4057 (24) P=0.049	-0.3661 (25) P=0.072	0.1484 (25) P=0.479	0.2272 (25) P=0.275	0.1606 (24) P=0.453
HITS IN PERIOD 5	-0.1082 (25) P=0.607	-0.1194 (24) P=0.579	-0.0796 (25) P=0.705	-0.2292 (24) P=0.281	0.3446 (25) P=0.092	0.1524 (25) P=0.467	0.0768 (25) P=0.715	0.0786 (24) P=0.715
SHOT-GROUP SIZE PERIOD 6	-0.1965 (26) P=0.336	-0.1793 (25) P=0.391	0.1519 (26) P=0.459	0.2136 (25) P=0.305	-0.3095 (26) P=0.124	-0.4120* (26) P=0.036	0.2207 (26) P=0.279	-0.1236 (25) P=0.556
HITS IN PERIOD 7	0.1868 (26) P=0.361	0.0459 (25) P=0.828	-0.4675* (26) P=0.016	-0.4187* (25) P=0.037	0.1628 (26) P=0.427	0.2118 (26) P=0.299	-0.1108 (26) P=0.590	-0.1235 (25) P=0.556
HITS IN PERIOD 8	0.3213 (26) P=0.109	-0.0202 (25) P=0.924	-0.1591 (26) P=0.438	-0.2700 (25) P=0.192	0.2284 (26) P=0.262	0.1736 (26) P=0.397	0.2867 (26) P=0.156	-0.0653 (25) P=0.757
HITS IN PERIOD 9	-0.1512 (22) P=0.502	-0.3051 (21) P=0.179	-0.2898 (22) P=0.191	-0.0826 (21) P=0.722	-0.0605 (22) P=0.789	0.0485 (22) P=0.830	0.1137 (22) P=0.614	0.0539 (22) P=0.812
PRACTICE RECORD FIRE	0.1411 (25) P=0.501	0.0602 (24) P=0.780	-0.1523 (25) P=0.467	-0.3412 (24) P=0.103	0.2064 (25) P=0.322	0.0403 (25) P=0.848	-0.1956 (25) P=0.349	0.0224 (25) P=0.915
COMBAT FIRE	-0.1409 (26) P=0.492	-0.3056 (25) P=0.137	-0.5514** (26) P=0.004	-0.5647** (25) P=0.003	-0.1354 (26) P=0.510	-0.0783 (26) P=0.704	-0.2125 (26) P=0.297	-0.1116 (25) P=0.595
RECORD FIRE	0.1077 (26) P=0.600	0.0413 (25) P=0.845	-0.2741 (26) P=0.175	-0.4005* (25) P=0.047	0.1633 (26) P=0.425	0.1135 (26) P=0.581	-0.2893 (26) P=0.152	0.0296 (25) P=0.888

* Indicates P < .05
** Indicates P < .01
*** Indicates P < .001

with 5 of the live-fire measures indicate a promising new measure. Is it possible that point-of-aim measures of accuracy are not the best predictors of marksmanship in the MACS system? Accuracy measures were used in the original evaluation (Perkins et al.) because they represented the most intuitive and traditional measure of performance in a marksmanship task. However, perhaps electronic simulators like MACS provide additional and more powerful measures of marksmanship ability which are not utilized because they have not been traditionally available.

There is another interesting feature in the present data. Although this study was the first time that MACS has been correlated with live-fire, in an earlier study (Schroeder, 1983b) MACS point-of-aim scores were found to significantly correlate with scores on another marksmanship simulator -- the Moving Target Rifle Marksmanship Trainer (MTRMT). Other research has shown that MTRMT scores correlate significantly with live fire (Schendel and Heller, 1982; and Schendel, Heller, Finley, and Hawley, 1983). This trend of results is incongruous with the generally low correlations of MACS point-of-aim scores with live-fire scores found in the present study. This apparant inconsistency caused the present author to review the MACS development effort to determine if any hardware and/or software changes could have resulted in the discrepancy between early MACS results and the present results. Hardware changes were unlikely to have caused the discrepancy since the reliability and accurracy of the light pen had actually been improved over the development effort. However, there was a seemingly insignificant software change that may have resulted in lower correlations in the present study. The change involves the MACS software and how it determines point-of-aim. In the original MACS software that the present author wrote, 5 light-pen readings were collected after the trigger-switch was closed. Since the software can provide readings at the rate of about 20 per sec, this represented a measurement window of about .25 sec. After the 5 light-pen readings were taken, both "X" readings (horizontal) and "Y" readings (vertical) were sorted and the medians were determined. This approach was taken to stabilize the light-pen readings and eliminate any potential deviant scores. It was this procedure that was used in the study which found significant correlations with the MTRMT. Subsequently, software contractors were brought in to make improvements in the software. The present author directed the software developers to change the above procedure in order to increase the speed of operation of the MACS system. In the new procedure, the light pen continuously took readings and updated a fixed stack. When the trigger-switch was closed, the last 5 X and Y readings before trigger-pull were sorted and medians calculated. The two procedures were functionally the same, except for the time window. Could a difference of .25 sec in the time window have resulted in the apparently large difference in results? Perhaps the answer is "yes" if small changes in the position of the weapon due to trigger manipulation affect both point-of-aim scores on a simulator and in live fire. More specifically, one of the most important principles in marksmanship is that the trigger should be squeezed because rapid trigger manipulation typically results in movement of the weapon and error in the subsequent shot. Using the 5 readings before trigger manipulation is less likely to pick up distortions in the point-of-aim than using the 5 readings after trigger manipulation for those poor shooters who quickly "jerk" the trigger. This is especially true given the median routine in the software that presumably sorts out deviant scores due to the light pen, but in this case, may be sorting out deviant scores that are due to shooting errors. Because this process would make poor shooters appear better than they really are, the range of the MACS scores would be restricted and the magnitudes of the correlations would be limited. In addition, this may explain why such a high percentage of the experimental MACS subjects in Perkins et al. scored very high.

on the MACS system (i.e., if holding the weapon steady during trigger manipulation is a key component to marksmanship and the second generation MACS software was not looking at that component, then perhaps MACS was measuring the ability to achieve a proper initial aiming point — a fairly easy task).

The two hypotheses discussed above suggest an interesting redirection for software development of the MACS system. First, studies need to be done to determine the optimum time window and statistical method for determining point-of-aim. This should be done using correlation with live fire as a criterion. Second, the high test-retest reliability shown in the variability measure reflecting steadiness in the weapon should be investigated as a possible meaningful measure for both the prediction of marksmanship ability and as a feedback variable for training marksmanship. In general, what is suggested by the present author is a correlational time-series type analysis that empirically determines the best window(s) and statistical method(s) for: predicting marksmanship, diagnosing and remediating marksmanship problems, and providing feedback for marksmanship training. The current expertise in marksmanship training should help guide this development effort. For example, in the Army's Basic Rifle Marksmanship Program of Instruction, the four fundamentals are: steady position, trigger squeeze, aiming, and breath control. If these are indeed fundamentals of marksmanship, then why not design a simulator/trainer that measures these four components (or as many as feasible). The new redirection in MACS software development will be to establish time windows and statistical methods which will hopefully measure at least three of these four areas: steady position, trigger squeeze, and aiming. Measures of variance for selected time windows should provide diagnostic, remedial, predictive, and training information for the steady position and trigger squeeze variables. Measures of central tendency for a selected time window should provide diagnostic, remedial, predictive, and training information for the aiming variable.

In the near future, research will be conducted which will identify the optimal windows and statistical measures. The next generation of MACS software will incorporate this information. Different programs will be written for the purpose of prediction of marksmanship ability, diagnosis and remediation of marksmanship problems, and for the general training of marksmanship skills on the M16A1 rifle and other MACS weapons.

References

Perkins, M. N., Selby, R. D., Broom, J. M., & Osborne, A. S., (1985). Preliminary evaluation of the Multipurpose Arcade Combat Simulator (MACS) for the M16, M203, and M72A2 (ARI Research Note 85-60). Alexandria, Virginia: U.S. Army Research Institute for the Behavioral and Social Sciences.

Schendel, J. D., & Heller, F. H. (1982). Use of Weaponeer marksmanship trainer in predicting M16A1 qualification. Proceedings of the Eighth Symposium Psychology in the Department of Defense (pp. 106-110).

Schendel, J. D., & Heller, F. H., Finley, D. L., & Hawley, J. K. (1983). Use of Weaponeer marksmanship trainer in predicting M16A1 rifle qualification performance (ARI Research Report 1370). Alexandria, Virginia: U.S. Army Research Institute for the Behavioral and Social Sciences.

Schroeder, J. E. (1983a). A Multipurpose Arcade Combat Simulator (MACS). ARI Technical Report 629. Alexandria, Virginia: U.S. Army Research Institute for the Behavioral and Social Sciences.

Schroeder, J. E. (1983b). The relationship between the Moving Target Rifle Marksmanship Trainer (MTRMT) and the Multipurpose Arcade Combat Simulator (MACS). ARI Research Note. Alexandria, Virginia: U.S. Army Research Institute for the Behavioral and Social Sciences.