

NOV 16 1969
NASA CR-101631

NASA SC/NGR-18-002-008
Report No. SSR-4
15 April 1969

Semiannual Status Report

PERFORMANCE MEASUREMENT OF NONVERBAL MEDIATION

TO: NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
Office of Grants and Research Contracts
Attention: Code SC
Washington, D. C. 20546

ON: Grant No. SC/NGR-18-002-008

FOR THE PERIOD: 1 October 1968 to 31 March 1969

PREPARED AND
SUBMITTED BY: Ben B. Morgan, Jr., Ph.D. & Earl A. Alluisi, Ph.D.

Performance Research Laboratory
University of Louisville
Louisville, Kentucky 40208

Semiannual Status Report No. SSR-4

1 October 1968 to 31 March 1969

PERFORMANCE MEASUREMENT OF NONVERBAL MEDIATION

SUMMARY

This is the fourth semiannual status report to be submitted under Grant No. SC/NGR-18-002-008, "Performance Measurement of Nonverbal Mediation." It covers the work completed during the six-month period, 1 October 1968 through 31 March 1969.

Work during this period has followed closely the lines presented in the proposal on which the grant is based (submitted 28 June 1968). Major efforts have been concerned with an investigation of the effects of practice and operator loading on the performance obtained with the digital-readout version of the COTRAN task; data analysis and the preparation of a preliminary report of this study were completed during this work period. In addition, the data analysis and report of a pilot investigation of the group-performance version of COTRAN were completed. A prototype group-performance COTRAN apparatus has been constructed as part of the MTP battery and a study is being planned to test this apparatus.

* * *

INTRODUCTION

This is the fourth semiannual status report to be submitted under Grant No. SC/NGR-18-002-008 between the University of Louisville and National Aeronautics and Space Administration. This research on the "Performance Measurement of Nonverbal Mediation" is being conducted under the direction of Dr. Earl A. Alluisi, Research Professor and Director, Performance Research Laboratory and is monitored by the Human Performance Branch, Biotechnology Division, Life Sciences, NASA Ames Research Center, Moffett Field, California. This report covers work completed during the six-month period, 1 October 1968 through 31 March 1969.

The purpose of the present research is to develop a task for the performance measurement of nonverbal mediation. The task is to meet certain criteria of validity, sensitivity, engineering feasibility, reliability, flexibility, work-load variability, trainability, and control-data availability as defined elsewhere (Alluisi, 1967; Alluisi & Fulkerson, 1964), and eventually will be used within a multiple-task performance (MTP) battery (Alluisi, 1967) to measure the

nonverbal-mediation aspects of work behavior. The specific goals established for this fourth year of research were as follows:

- o To complete the analyses and report the results of all studies not completed and reported during the past year.
- o To conduct additional experiments as needed, employing either the digital-readout or the group-performance version of the COTRAN task, in order to obtain data on the basis of which a final decision can be made regarding which version of the COTRAN task can best be incorporated into the MTP battery.

In reporting on the status of the research in this report, the general outline presented in the semiannual status report of 15 April 1966 will continue to be used, with appropriate additions, to provide for continuity without sacrifice of brevity.

1. DEVELOPMENT OF THE COTRAN TASK

1.1 Background in performance measurement. --No additional work has been required in this area; see "Introduction" and "Background in Performance Measurement," pp. 2-4 of the initial "Proposal for Research" (dated 9 June 1965).

1.2 Background in measuring nonverbal mediation. --No additional work has been required in this area; see "Background in Measuring Intellectual Functioning," pp. 4-5 of the initial proposal (dated 9 June 1965). A review of this background material will be prepared for possible publication in a psychological journal.

1.3 The COTRAN task. --No additional work has been required in the development of the COTRAN task. Three versions of the task have been developed; i. e., the basic three-phase (3P-COTRAN), the digital-readout (DR-COTRAN), and the group-performance (GP-COTRAN) versions. Each of these was described fully in the semiannual status report of 15 April 1968 (pp. 4-5).

2. DESIGN AND CONSTRUCTION OF COTRAN APPARATUS

2.1 Prototype equipment. --The temporary modification of the solid-state prototype of the COTRAN apparatus (to permit its use as a group-performance task) has been disassembled; the solid-state equipment is now used solely as a 3P-COTRAN task. However, a prototype of the GP-COTRAN apparatus was constructed (under support from Army Contract No. DA-49-193-MD-2567) by modifying the code-lock equipment of the MTP battery so as to permit its use with punched tape input as either a code-lock or a GP-COTRAN task. A paper tape consisting of 432 COTRAN problems was punched and run through the apparatus without error in the tape or malfunction in the equipment. Thus,

the reliability of this prototype appears to be extremely high. The current apparatus is a temporary construction, but if a decision is made to add the GP-COTRAN task to the MTP battery, the modification will be incorporated permanently into the MTP equipment.

2.2 Standardized equipment. --No additional progress has been made in this area during the past six months. It is anticipated, however, that a standardized design of the solid-state prototype equipment will be completed before the end of the research program.

3. SINGLE-TASK STUDIES OF COTRAN PERFORMANCE

3.1 Studies of the parameters of the COTRAN task. --The results of this study were reported as a NASA Contractor Report (see Submitted Reports, Item 1), and presented at the meetings of the Southern Society for Philosophy and Psychology, Roanoke, Virginia, March, 1967. In addition, a report of this study has been submitted for possible publication in Perceptual and Motor Skills.

3.2 Studies of the reliabilities of the COTRAN measures. --No additional work has been completed in this area with respect to the 3P-COTRAN task; the reliability coefficients of the 3P-COTRAN measures were reported in the initial NASA Contractor Report (see Submitted Reports, Item 1, pp. 28-29), and presented at the meetings of the Southern Society for Philosophy and Psychology, Roanoke, Virginia, March, 1967. However, reliability coefficients of the DR-COTRAN measures are in the process of being computed (from the data of the study reported in section 3.9), and these will also be reported as a NASA Contractor Report (see Submitted Reports, Item 3).

3.3 Correlational studies of COTRAN performance. --No additional work has been completed in this area with respect to the 3P-COTRAN task; a report of the correlation study of 3P-COTRAN performance was included in the initial NASA Contractor Report (see Submitted Reports, Item 1), and presented at the meetings of the Southern Society for Philosophy and Psychology, Roanoke, Virginia, March, 1967. However, the correlations of seven measures of DR-COTRAN performance with appropriate paper-and-pencil measures of intellectual abilities are in the process of being computed. These results (a continuation of the study reported in section 3.9) will also be submitted as a NASA Contractor Report (see Submitted Reports, Item 3).

3.4 Effects of practice on the performance of a code transformation task (3P-COTRAN). --No additional work has been completed in this area; the results of this study were reported as a NASA Contractor Report (see Submitted Reports, Item 2). In addition, a report of this study will be

presented at the meetings of the Southern Society for Philosophy and Psychology, Miami, Florida, April, 1969.

3.5 Factor structure of the digital-readout version. --Two studies employing the DR-COTRAN task have been conducted in order to provide a detailed analysis of performance on this task (viz., its factor structure). In both studies, thirteen measures were computed, and these were intercorrelated and factor analyzed.

The results of the first study (reported in the semiannual status report of 15 April 1968) indicated that the factor structure of DR-COTRAN performance was essentially identical to the "problem-solving," or phase-III performance obtained with the 3P-COTRAN task.

During the second study (reported in section 3.9) twenty subjects were required to solve 27 DR-COTRAN problems during each of four successive sessions. The factor analyses of these data resulted in the identification of the same three DR-COTRAN factors obtained in the first study. The three factors obtained were identified as follows: (1) Factor I, general problem solving, (2) Factor II, errors in problem solving, and (3) Factor III, time in problem solving. The correlations of the corresponding factors obtained in the four performance sessions produced coefficients of correlation all in excess of .98 ($P < .01$ in each case). In addition, the correlation of corresponding factors of the present study with those of the first study produced correlation coefficients all in excess of .95 ($P < .01$ in each case).

It was concluded that the factorial structure of DR-COTRAN performance remains essentially constant across different levels of practice, as well as across different subjects and experimental conditions.

3.6 Paper-and-pencil studies of COTRAN performance. --No additional work has been completed in this area.

3.7 Effects of illness on COTRAN performance. --A report of this study, which was conducted in connection with work on the "Behavioral Effects of Infectious Diseases" under Contract No. DA-49-193-MD 2567 with the U. S. Army Medical Research and Development Command, has been written and will be published initially as Appendix E of an Interim Technical Report to be submitted under the above named contract (Coates, Alluisi, Thurmond, and Morgan, in preparation).

3.8 Group-performance version of the COTRAN task (GP-COTRAN). --The results obtained in the first phase of this pilot investigation (reported in the semiannual status report of 15 April 1968) were quite straightforward: (1) performance on the GP-COTRAN task appeared to reach asymptotic levels during sessions four to six, and (2) performance in phase III was substantially improved with the use of memory aids, whereas performance in phases I and II was unaffected.

On the basis of these results, the study was extended into an investigation of the effects of time-sharing different combinations of tasks from the MTP battery on performance of the GP-COTRAN task. The study was also designed so as to permit a comparison of performance on the GP-COTRAN task with performance on the code-lock solving task from the MTP battery.

A group of five subjects served in each of six experimental sessions. Each session was divided into eight, 15-minute periods, each of which was followed by a five-minute rest period. The code-lock task was presented during sessions 1 and 6, and the COTRAN task was presented concurrently with one of two time-sharing loads of MTP tasks during sessions 2 through 5. Specifically, during sessions 1 and 6, the subjects were required to solve the code-lock task concurrently with the three MTP watchkeeping tasks (warning-lights, blinking-lights, and probability monitoring). These two conditions were identical except for the experience acquired between sessions 1 and 6. During sessions 2 and 5, GP-COTRAN was presented concurrently with the watchkeeping tasks. These two conditions differed in that during session 5 the GP-COTRAN task was modified so as to produce a 30-second delay between phases II and III of each problem. The subjects were instructed to arrive at a mental solution to the problem during this no-response interval and to enter the solution as rapidly as possible at the beginning of phase III; this change made the response characteristics of phase III identical to those of the repeat phase of the code-lock problems.

During sessions 3 and 4, the subjects were required to solve GP-COTRAN concurrently with the watchkeeping tasks and the target identification task (TID). These two conditions also differed with respect to the delay between phases II and III of the COTRAN problems; there was a 30-second delay during session 4 but no delay during session 3.

Performance was analyzed separately for each of the tasks employed. The results of those analyses supported the following conclusions:

- 1) The addition of the 30-second delay between phases II and III of the GP-COTRAN problems had no effect on performance of the TID task. Its only effect on the watchkeeping tasks was to allow better performance during the condition of greatest work load (COTRAN plus TID and watchkeeping). Finally, it changed the response characteristics of phase III of the GP-COTRAN problems so as to reduce the time required to enter a phase-III solution.

- 2) COTRAN performance (in terms of both accuracy and response speed) was decreased during the heaviest work-load condition. Thus, GP-COTRAN seems to be sensitive to the stress provided by increased work-load.

- 3) Comparisons of GP-COTRAN performance with performance on the code-lock task indicated that performance in solving the original sequences of code-lock was essentially identical to performance during phases I and II of GP-COTRAN. This result is not surprising since the response requirements

of phases I and II of GP-COTRAN are identical to those of the original code-lock sequences. Finally, other comparisons indicate (although not conclusively) that performance in phase III of those GP-COTRAN problems in which a 30-second delay was imposed between phases II and III did not differ from performance in solving the repeat sequences of code-lock. Again, this result was expected on the basis of the inherent similarities in response requirements.

4) The major conclusion to be drawn from this study is that the feasibility of employing the GP-COTRAN task within the MTP battery has been demonstrated. Furthermore, it appears that if used instead of the code-lock task, the GP-COTRAN task would provide for the measurement of those aspects of performance already measured by code lock as well as certain communication aspects measured in phase III of GP-COTRAN.

3.9 Effects of practice on the performance of a digital-readout version of a code transformation task (DR-COTRAN). --In this experiment 27 DR-COTRAN problems were solved during each of four consecutive sessions scheduled on two successive days.

The results of the analyses of these data indicated that (1) the factorial structure of DR-COTRAN performance remained constant across the four sessions of practice, as well as across the different subjects and experimental conditions employed here and in previous studies. Also, (2) the levels of performance increased with practice through the four sessions. Finally, (3) the effects of transformation complexity were evidenced during early stages of practice as well as during post-acquisition skilled performance. In comparison to 3P-COTRAN findings, which indicate that transformation complexity is a significant variable only during skilled performance, these results indicate that transformation complexity affects DR-COTRAN performance during all stages of practice. A complete report of this study is in preparation and will be submitted as a NASA Contractor Report (see Submitted Reports, Item 3).

4. MULTIPLE-TASK STUDIES OF COTRAN PERFORMANCE

4.1 Effects of work-load stress on 3P-COTRAN performance. --No additional work has been completed in this area; the results of this study were reported as a NASA Contractor Report (see Submitted Reports, Item 2), and will be presented at the meetings of the American Psychological Association, Washington, D. C., August, 1969.

4.2 Effects of operator loading on performance with the DR-COTRAN task. --This investigation was conducted as a continuation of the experiment reported in section 3.9. During this phase of the investigation, each of 20 subjects solved 27 DR-COTRAN problems during each of three successive sessions; they were required to time-share the DR-COTRAN task with different combinations of tasks selected from the MTP battery. The results indicated that skilled DR-COTRAN performance is sensitive to at least two levels of work-load stress, and

that different subjects tend to adopt different strategies in time-sharing the DR-COTRAN task with other tasks. The strategies that subjects adopt reflect further differences in the levels of work-load stress employed. It was concluded that these results essentially parallel those obtained with 3P-COTRAN under the same conditions. A report of this study is in preparation and will be submitted as a NASA Contractor Report (see Submitted Reports, Item 3). In addition, this study will be presented at the meetings of the American Psychological Association, Washington, D. C., August, 1969.

4.3 Multiple-task studies of the GP-COTRAN task. --Plans are being made to extend the pilot investigation reported in section 3.8 into a study of the effects of time-sharing different combinations of tasks from the MTP battery on performance of group-performance COTRAN. The study will be similar in design and purpose to those reported in sections 4.1 and 4.2. The results of this investigation should permit decisions to be made concerning the optimum nature and direction of future research with the group-performance COTRAN task.

REFERENCES

- Alluisi, E. A. Methodology in the use of synthetic tasks to assess complex performance. Hum. Factors, 1967, 9, 375-384.
- Alluisi, E. A. & Coates, G. D. Parameters and factor structure of a three-phase code transformation task (3P-COTRAN). Submitted for possible publication in Percept. Mot. Skills.
- Alluisi, E. A. & Fulkerson, S. C. Behavioral effects of infectious diseases: Semi-annual progress report, 1 March 1964-31 August 1964. Univer. Louisville Perf. Res. Lab. Rep., 1964, No. RR-64-2.
- Coates, G. D., Alluisi, E. A., Thurmond, J. B., & Morgan, B. B., Jr. Two studies of the behavioral effects of Phlebotomus fever in man. Univer. Louisville Perf. Res. Lab. Rep., in preparation.

LIAISON ACTIVITIES

Dr. W. Dean Chiles, Chief, Human Performance Research, Civil Aero-medical Institute, FAA, Oklahoma City, Oklahoma, visited the laboratory on 1-2 October 1968 to consult on related performance research. During the period 31 October - 2 November, Drs. Coates and Thurmond attended the Ninth Annual Meeting of the Psychonomic Society held at St. Louis, Missouri. During the period 12-13 December 1968, Dr. Alluisi visited the Texas Christian University Research Foundation in Fort Worth, Texas where he served as chairman of a conference on pattern perception. Dr. Coates visited the Psychology Department of Northern Illinois University at DeKalb, Illinois on 14 February

1969 to present a colloquium on the research conducted in the Performance Research Laboratory. During the period 5-9 March 1969, Dr. Alluisi visited the University of California at Los Angeles, Los Angeles, California where he lectured in a short course in "Psychological Factors in Systems." On 20-21 March 1969 he visited Fort Detrick, Maryland to discuss research plans for the Summer 1969.

Dr. Aaron Hyman, Deputy Director for Human Performance Experimentation, U. S. Army Behavioral Science Research Laboratory visited on 5 December 1968 in connection with the Laboratory's Project-THEMIS contract; Dr. Hyman and Dr. Lynn E. Baker, U. S. Army Chief Psychologist, Army Research Office visited on 2 January 1969 for similar reasons. Dr. Robert Hottenberg of the 6570th Personnel Research Laboratory, Aerospace Medical Division of Lackland Air Force Base, Texas visited the laboratory on 28 February 1969.

DIFFICULTIES ENCOUNTERED

No unsolvable difficulties were encountered during this period and work is progressing on schedule.

ANTICIPATED WORK

The remainder of the period of this grant will be devoted to data collection and analysis, and the preparation of reports in connection with the planned investigation of the group-performance version of the COTRAN task. It is anticipated that work on this project will be postponed during the coming summer because of personnel and equipment commitments to a long-term study of the "Behavioral Effects of Infectious Diseases," under Contract No. DA-49-193-MD-2567 with the U. S. Army Research and Development Command. The final experiment, therefore, will have to be postponed to the fall when the MTP battery has been returned from Fort Detrick, Maryland; an extension of the present contract, at no additional cost to NASA, will be requested as soon as final plans for the summer have been made.

PERSONNEL

The personnel employed on this grant during the past six months were E. A. Alluisi (Principal Investigator), G. D. Coates, T. K. Dempsey, P. R. Gaddie, Judith A. Hunt, Vicki M. Matix, B. B. Morgan, Jr., K. E. Rothrock, Eleanore B. Sewell, and Nancy L. Wild.

SUBMITTED REPORTS

Previously Submitted

1. Alluisi, E. A. & Coates, G. D. A code transformation task that provides performance measures of nonverbal mediation (COTRAN). NASA Contractor Report, 1967, No. CR-895.
2. Alluisi, E. A. & Morgan, B. B., Jr. Effects of practice and work load on the performance of a code transformation task (COTRAN). NASA Contractor Report, 1968, No. CR-1261.


In Preparation

3. Alluisi, E. A., Dempsey, T. K. & Morgan, B. B., Jr. Effects of practice and operator loading on the performance of a digital-readout version of a code transformation task (DR-COTRAN). NASA Contractor Report, in preparation.


OTHER REPORTS

1. Coates, G. D. A performance task of intellectual functioning. Unpublished doctoral dissertation, Univer. Louisville, 1966.
2. Coates, G. D. A code transformation task that provides performance measures of nonverbal mediation (COTRAN). Paper presented at South. Soc. Philos. Psychol., Roanoke, Va., March 1967.
3. Alluisi, E. A. & Chiles, W. D. Sustained performance, work-rest scheduling, and diurnal rhythms in man. Acta Psychol., 1967, 27, 436-442.
4. Morgan, B. B., Jr. The acquisition and performance of a problem-solving skill. Unpublished doctoral dissertation, Univer. Louisville, 1968.
5. Dempsey, T. K. Effects of operator loading on performance of a digital-readout version of the COTRAN task. Unpublished master's thesis, Univer. Louisville, 1969.
6. Morgan, B. B., Jr. The acquisition of a problem-solving skill. Paper presented at South. Soc. Philos. Psychol., Miami, Fla., April 1969. (Received SSPP Junior Award in Psychology)

PREPARED AND SUBMITTED BY:


Ben B. Morgan, Jr., Ph.D.
Assistant Research Professor

and


E. A. Alluisi, Ph.D.
Research Professor and Director

DISTRIBUTION

- 10 -- Office of Grants and Research Contracts
Attention: Code SC
National Aeronautics and Space Administration
Washington, D. C. 20546
- 2 -- Dr. Mark Patton
Human Performance Branch
NASA Ames Research Center
Moffett Field, California
- 1 -- ea addressee, Performance Research Laboratory distribution list.