

N82-13679

D14

IDENTIFICATION OF COGNITIVE FACTORS RELATED TO REMOTE WORK PERFORMANCE
USING CLOSED CIRCUIT TV DISPLAYS*

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SUMMARY

This paper describes research at the Oak Ridge National Laboratory which identifies operator perceptual-cognitive styles as predictors of remote task performance. Of particular interest are those remote tasks which require the use of servo-controlled master-slave manipulators and closed circuit television for teleoperator repair and maintenance of nuclear fuel recycling systems. At the present time data analysis is incomplete; therefore, this paper suggests a useful procedure for identifying such perceptual styles, rather than giving definitive results.

INTRODUCTION

The particular aspects of man/machine interface for the ORNL fuel recycle program have been described previously (1). This facility will employ remote viewing and manipulator control systems. In general, however, manipulator control using closed circuit television, involving the remote movement of mass with limited visual information, is analogous to other remote movement tasks such as vehicle piloting. In both situations the operator or pilot moves mass at a distance under some constraint in regards to available visual information. Therefore, it seemed reasonable to assume that previous research concerning perceptual-cognitive abilities as related to piloting/navigation tasks would be applicable to the present problem, particularly since there is a dearth of literature concerning perceptual cognitive abilities relating to manipulator control skills. Generally, people who can function perceptually in the presence of misleading, distracting, or conflicting information have been found to be superior at various remote control tasks: navy pilots (2), nonpilot navigators and intercept operators (3), and automobile drivers (4,5).

*Research sponsored by the Office of Nuclear Fuel Cycle, U.S. Department of Energy, under contract No. W-7405-ENG-26 with Union Carbide Corporation.

EXPERIMENTAL PROCEDURES

To evaluate the relationship between perceptual-cognitive functioning and remote handling ability, a group of inexperienced subjects were administered a battery of perceptual-cognitive tests to measure perceptual functioning in the presence of conflicting or distracting perceptual inputs. Subjects were then briefed and received preliminary training in the use of manipulators for remote handling tasks using closed circuit television displays as the primary mode of information feedback. It was hypothesized that subjects' perceptual test scores would predict training results regarding level of performance and speed of learning.

Subjects

Forty-seven employees (26 male and 21 female) of Oak Ridge National Laboratory or Oak Ridge Associated Universities volunteered as subjects. No subject had prior manipulator experience. All subjects received an in-depth vision screening for acuity and phorias (near and far) and depth and color perception. Subjects were asked to fill out a biographical questionnaire which contained many items with possible relevance to remote task performance. Items covered age, sex, preferred hand (right or left), occupation, education, sports activities, and television viewing habits. A question was also included concerning motion sickness history since previous literature (3) has indicated that such sickness may result from the way subjects react to conflicting perceptual inputs and may be predictive of remote control training results.

Groups Perceptual-Cognitive Tests

All subjects were administered three group perceptual tests prior to exposure to remote tasks:

1. Hidden Figures Test, which measures flexibility of closure and which is related to the "field independence" cognitive style (6).
2. Paper Folding Test, which measures the ability to mentally restructure a visualized figure into components, and involves the serial mental rotation of a spatial configuration in short-term memory (6).
3. Manikin Test, an experimental group perceptual test refined at Oak Ridge Associated Universities, which demands that subjects make rapid decisions about the spatial orientation of visual stimuli.

Remote Test Station Layout

Subjects performed the experimental remote tasks with master-slave M-8 manipulators. A 25-in. TV monitor was placed between the master arms at eye level on a solid partition simulating a division between the task (cell) area and the operating area. The operating area was diffusely lighted and surrounded by canvas curtains. A chair was placed at a distance of four times the monitor height from the monitor. To keep viewing distance constant, the subjects were asked to remain seated while they used the manipulators. The layout was measured in S.I. units.

The slave side of the partition was also surrounded by canvas curtains and was brightly lighted at approximately 343 candelas/meter (100 foot-lamberts). Intermittent measures on illumination were taken throughout the testing. The board on which the individual tasks were performed was painted gray-blue.

Television cameras were installed in positions 45° above horizontal in the sagittal plane and at an offset position at 30° elevation and 45° to the left side of the sagittal plane.

Test Procedures for Remote Tasks

Subjects were given a demonstration in the use of a manipulator and then allowed to practice freely for 30 min. placing twelve, 2.5-cm wooden cubes in a 30-cm high steel pot. They were then asked to perform fairly simple remote tasks, three trials for each.

Task 1. Build a 3-2-1 pyramid with the cubes.

Task 2. Take out and replace 7.5-cm high wooden geometrical shapes from a form board.

Task 3. Unscrew, place on table, pick up, and rescrew a 2.5-cm bolt from a steel plate.

All tasks were performed with the camera at the offset position. Subjects were then asked to repeat the bolt test with the camera at 45° above horizontal, which unpublished work by the first author has shown to be a disorienting view.

Subjects returned individually, approximately four weeks later, and repeated the total remote task sequence.

ANALYSIS AND RESULTS

The predictive validity of the group perceptual tests, and of the biographical items is being assessed in terms of the results of remote task performance. Preliminary regression analysis indicates that the Hidden Figures Test is a useful predictor, accounting for a significant proportion of the variance in measures of remote training outcome. The relationship between this test and training outcomes remains when any confounding effect of sex is removed from the data. (This procedure is necessary because women often perform more poorly on such tests.) Results, therefore, suggest the usefulness of group perceptual cognitive tests such as Hidden Figures, in future remote operator selection and training programs.

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