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# Bureau of Naval Personnel

## ● Research Report ●

### ANALYSIS OF THE RELATIVE MOVEMENT TEST BY A METHOD OF INDIVIDUAL INTERVIEWS

by

Charles M. Lucas  
Educational Testing Service  
Princeton, New Jersey

MARCH 1953

Prepared under contract Nonr-694 (00) with the Office of Naval Research  
Project Designation NR 151-13

**Classification and Survey Research Branch  
Research Division**



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Abstract

The purpose of this study was to analyze performance on the Relative Movement Test, a part of the U. S. Navy Officer Classification Battery, in order to obtain a better understanding of what the test measures. More adequate information about the test should be of value in indicating how more effective measures may be produced for use by the Navy in selection and classification of personnel.

A preliminary analysis of answer sheets for the Relative Movement Test revealed that under normal administration conditions the test is speeded. The proportion of items not reached was considerably greater for the Relative Movement Test than for the other tests in the battery.

The analysis to be described here was based on data obtained from individual interviews. A sample of officer candidates, who had previously taken the test, were asked individually to do the problems aloud in an interview situation. Each subject described how he solved each of the group of selected items presented to him. All interviews were tape-recorded.

At a later date, six judges listened to the recordings for the first 20 items of the test, and each judge wrote a description of the mental process he thought was involved in each solution. These descriptions were then sorted into categories according to type of mental process described and also according to item number.

The findings were as follows:

1. The test seems to provide a measure of spatial and deductive ability. The element of speededness in the regular examination procedure very likely provides a modifying condition, however.
2. Three groups of items were identified: (1) those judged to be primarily spatial, (2) those judged to be primarily de-

ductive, and (3) those judged to be both spatial and deductive to an approximately equal extent.

3. Items judged as primarily spatial were generally the ones that required course or bearing answers, whereas those judged as primarily deductive generally required relative speed answers.
4. There was almost universal agreement among judges that spatial and deductive processes were involved in all but few of the reports. Judges differed among themselves with respect to the predominance of spatial and deductive processes.
5. No subject showed a tendency to employ any one of the above-mentioned processes consistently from item to item. Processes were found to vary more as a function of the item than as a function of the subject.

It was recommended that studies should be performed in order to discover the relative validities of spatial items, deductive items, and items which involve both spatial and deductive ability, both under speeded and unspeeded conditions. Such studies would provide the final evidence regarding how best to use Relative Movement Test items in selection and classification of Naval personnel.

Acknowledgements

Acknowledgment is made to Captain Ralph C. Johnson, Commanding Officer, U. S. Naval Schools Command, U. S. Naval Station, Newport, Rhode Island, for making available to Educational Testing Service the facilities under his command. His interest and cooperation have made this research possible.

Also acknowledged are the assistance and cooperation of Lieutenant Commander George B. Strother, Interviewing Officer, and his staff. Appreciated are the many specific instances when Commander Strother's cooperation extended to making arrangements for the subjects, equipment, and space necessary for the smooth execution of data gathering.

ANALYSIS OF THE RELATIVE MOVEMENT TEST  
BY A METHOD OF INDIVIDUAL INTERVIEWS

Charles M. Lucas

Purpose.

The purpose of the present study was to analyze performance on the Relative Movement Test in order to obtain a better understanding of what the test measures. Stuit's book<sup>1</sup> indicates that an earlier form of the test was found to be a good predictor of success in such schools as tactical radar, fighter director, and sonar. Partly because of these findings and partly because it did not correlate highly with other tests in the battery, the present form of the Relative Movement Test was incorporated into the U. S. Navy Officer Classification Battery, which also includes tests of mathematics, verbal reasoning, mechanical comprehension, block assembly, and block recognition. It has since become apparent that more adequate information concerning what the Relative Movement Test measures should be of value in indicating how more effective measures may be produced for use by the Navy in selection and classification of personnel.

The Method.

The present report deals with one of the two approaches<sup>2</sup> employed in order to accomplish this purpose. This approach involves an analysis of the responses of a sample of individuals who have taken the test and who are later asked individually to do the problems aloud in an interview situation. The approach is not a new one. Dr. John Dailey conducted a study at the Psychological Research Unit at San Antonio during World War II in which aviation cadets who had taken the Mechanical Principles Test were asked in individual interviews to indicate

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<sup>1</sup>Stuit, Dewey B. (editor) Personnel Research and Test Development in the Bureau of Naval Personnel. Princeton, N.J.: Princeton University Press, 1947.

<sup>2</sup>The second was a factorial approach in which the Relative Movement Test was included in a battery of appropriate standard reference measures for the purpose of factorial analysis.

how they arrived at their particular responses. Bloom and Broder<sup>3</sup> at the University of Chicago investigated deductive processes by a similar procedure. The method itself appears to have distinct advantages, in that the likelihood of pre-structuring and therefore to some extent prejudicing the nature of the data is small. It is reasonable to expect that the free-response interview situation would tend to produce data of a broader and richer nature than might otherwise be possible.

The method of individual interviews has at least one obvious limitation, especially when it is applied for the purpose of analyzing a test that is normally administered in a context quite different from that of the interview situation. The Relative Movement Test is normally administered under timed conditions in a group situation to examinees who are aware that scores on this test play a role in evaluation and assignment to various billets or to advanced officer training. Therefore it is reasonable to expect a certain amount of tension to be present in the examining room.

In contrast, an individual interview situation of a permissive type, where the subject is encouraged to verbalize freely in conveying to the interviewer a notion of how he solved each of the problems presented, tends to free the subject from tension and pressure for speed. As the method was applied in the present study, subjects solved each problem in turn and explained how they did so, all under time conditions that were designed to be more than adequate for the task. Furthermore, subjects were told that the interviews had nothing to do with evaluation and placement. Consequently any findings that may result from an analysis of test responses in an interview situation may fall short of completely explaining the operation of the same test in the examining room.

#### Description of the Relative Movement Test.

The 50 items of the Relative Movement Test consist of verbal statements about the maneuvers of one or more ships in terms of such variables as speed, direction, distance, and time. The examinee is required to

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<sup>3</sup>Bloom, Benjamin S., and Broder, Lois J. Problem solving processes of college students. An exploratory investigation. Supplementary Educational Monograph 73, Univ. Chicago Press, 1952.

choose, without the aid of plotting or calculating on paper, the correct answer from the four alternatives presented. Groups of alternatives are usually stated in terms of a bearing, a course, or a relative speed or distance. The time limit for the current edition of the test is 30 minutes. The following serves to illustrate the general character of the items.

Ship A is steering northeast at 15 knots against a current of 3 knots. At 5 o'clock a lookout on Ship A sights Ship B 3 miles directly west. At 6 o'clock Ship A steers north. At 7 o'clock Ship B is detected 9 miles to the southeast. Ship B's course is: (1) southeast (2) northeast (3) north (4) it is impossible to tell from those data.

Preliminary Analysis of Responses to the Relative Movement Test.

Two sets of Officer Classification Battery answer sheets, one for an Officer Candidate class at Newport and one for a U. S. Naval Academy group, were examined. This study revealed that for a large proportion of examinees, responses to many items in the latter part of the Relative Movement Test were incorrect and were often marked according to certain apparently deliberate non-chance patterns (all remaining items marked choice 3, for example, or marked 1-2-3-4-3-2-1). A frequency tabulation of last-item-reached before omitting all subsequent items and of last-item-reached before detectable non-chance patterning for the Officer Candidate group demonstrated that by the time Item 25 was reached, 13% of the examinees had already been omitting or marking according to a non-chance pattern. At the Item-37 point, 50% of the answer sheets showed on-going or just-initiated non-chance patterning or omission of all subsequent items. Only about 25% of the answer sheets showed none of the above phenomena. And finally, the correlation coefficient between the first half and the second half of the test, scored separately, was found to be .10. Similar non-chance patterning and omitting was found in the answer sheets of the U. S. Naval Academy group, although this type of behavior tended to be initiated somewhat later in the test.

Examination of the other sub-tests in the battery, both for the Naval Academy group and for the Officer Candidate group, revealed that comparable omitting and non-chance patterning did not occur to a notice-

able extent except for the Mathematics Test, and even there it was not markedly extensive. For the 50-item Mathematics Test, 50% of the answer sheets showed on-going or just-initiated non-chance patterning or omission of all subsequent items at the Item-45 point.

A reasonable interpretation that may be given to omission of items and non-chance patterning is that examinees so responding found themselves far from completing the test with the time limit close at hand. As a result they either omitted all subsequent items or marked the remaining spaces on the answer sheet without considering the items. Since this occurred for a clear majority of the answer sheets in a sample of 400 selected at random from 1200 available papers, scores on the Relative Movement Test, as normally administered, are apparently a function of both speed and ability to solve the problems correctly. The practically zero correlation between the first and second halves of the test is further evidence of its speededness. Finally, the comparative lack of speededness in the other tests of the Officer Classification Battery may account for the comparatively low correlations that have been reported between the Relative Movement Test and those other tests.

It would appear, then, that the Relative Movement Test is a speeded measure and that it is unique among the other tests of the battery in this respect. Any findings that may stem from an analysis of responses occurring in an unspeeded interview situation must therefore take account of this speed factor if conclusions about the Relative Movement Test, as it functions in the Officer Classification Battery, are to be as close as possible to the facts.

#### Selection of Items for Analysis by the Interview Method.

It was decided to devote approximately 70% of the available interview time to the first 20 items of the test, and the remaining 30% to Items 21 through 50. There were two reasons for this decision: The first 20 items of the Relative Movement Test apparently contributed most heavily to the total scores of most of the examinees, and time limitations made impossible the scheduling of a sufficiently large number of different interviews for all 50 items of the test. Hence, while inter-

view material was gathered for the whole test, most of it was based on the first 20 items.

Fitting the study into the schedule at Officer Candidate School allowed interviews of no longer than 30 minutes. Consequently no more than seven items of the Relative Movement Test were presented to each subject. The items in each group of seven were made to vary systematically from subject to subject so that for blocks of 15 subjects the item groups would never be identical.

The selection of particular items for each group of seven was accomplished as follows. Tetrachoric intercorrelation coefficients for the first 20 items of the test were computed and then studied by an independent judge for the purpose of detecting any clustering of items. Three fairly clear, but overlapping, clusters were found in addition to three others that were less clear. The first five items of each group of seven were then selected by taking one item from each of the five clusters. Thus the factorial content of each item-group was as nearly as possible representative of the whole group of 20 items. The additional two items of each group of seven were then selected systematically from the last 30 items of the test. The complete cycle of 15 groups of seven items each was repeated three times to accommodate the 42 subjects who were interviewed. Item 8 was not presented to subjects because that item had been so designed that it could not be answered without first doing Item 7. Consequently either Item 9 or Item 10 was substituted for Item 8 in the interview situation.

#### Procedure.

All interviews were conducted by the writer at the U. S. Naval School, Officer Candidate, Newport, Rhode Island, during the week of May 5, 1952. At this time all members of the 6A class were being scheduled for conferences with personnel officers at the rate of three per hour. Out of each group of three, two were picked at random for the interviews. During separate interview periods of 25 minutes, each officer candidate was asked to verbalize the mental processes that he used in solving each of the problems presented to him. One

group of seven items was presented to each subject, one item at a time. Each item had been typed separately on a 5 x 8 card. At those times of the day when subjects were available, a maximum of two subjects per hour were interviewed. Responses of the subjects were tape-recorded.

Introductory remarks and instructions to all subjects were substantially as follows:

When you took the Officer Classification Battery you probably remember taking the Relative Movement Test. The purpose of this interview is to find out what a person must do to solve the kinds of problems found in the Relative Movement Test. This interview will in no way affect your present test score and will have nothing to do with your future classification. You were asked to come in for this interview for no reason except that you happened to be chosen at random from the 6A class. Also, your being chosen has nothing to do with your score on the test.

First I am going to give you a printed sheet of directions to read to yourself; then I will give you seven problems from the Relative Movement Test, one at a time. For each one, you are to read the problem through and figure out what the answer is. Then I want you to tell me how you arrived at the answer-- in other words, I want you to verbalize as if you were reasoning it through aloud in order to pick the correct answer. Tell me what you did and what went on in your head as you were doing it. This part of the interview will be tape-recorded for research purposes only. You will have ample time to do each of the seven problems and I will not be timing you. Do you have any questions?

The above instructions were elaborated whenever subjects raised questions about the procedure itself or the implications of the interview. Remarks of the interviewer were kept as non-leading as possible. At no time did the interviewer inform subjects as to the correctness of their solutions. Subjects were occasionally asked to elaborate what they meant when they used such terms as "visualize." All subjects were cooperative and all interviews proceeded smoothly. By the fifth and last day of interviewing a total of 42 officer candidates had been interviewed and their statements recorded.

Treatment of the Data.

Recording tapes were then cut up and reassembled so that all interviews for a given item would appear together and thus could be handled with greater facility during later judging sessions. Of the 42 recorded interviews, four were found to be unusable, due to an imperfection in a spool of tape. Code numbers were assigned to each subject and a record was kept of the items presented to each subject.

After all interview material was reassembled, a group of six judges from the research staff at ETS, including the writer, met as a group for several one-hour periods in order to listen to the recordings. Judges either described what each subject had done in order to solve each of the problems presented, or named the process or processes involved. Each judge wrote his description on a separate 3 x 5 card which also contained subject code number, item number, and judge code number. After the end of the seventh judging hour, when Item 20 had been completed, it was observed that subjects' reports in connection with the later items were not showing anything new or different from those of previously judged items, and it was decided that Items 21 through 30 could, at least for the time being, remain unjudged. At the close of the judging sessions each of the six judges had made 186 judgments of the reports of 38 subjects. After the judging sessions were completed, each judge prepared definitions of the terms used by him in describing the recorded material.

Judges' definitions of named processes were then studied and compared with one another. Differing definitions for identical terms, and vice versa, were reconciled and overlapping definitions were combined into composites. The result was a master-list of all definitions and terms used by all judges. All 1116 3 x 5 cards were then interpreted by means of the master-list and sorted according to its categories. The sorting procedure remained flexible to the extent that additional categories were initiated for those descriptions that did not fit any of the master-list categories.

### Findings.

Most of the judge-prepared descriptions fell into three major categories--spatial, deductive, and a mixture of both spatial and deductive. Definitions of these categories appear below.

Spatial. The ability to perceive patterns of objects in space, e.g., picturing the routes of the ships and then measuring distances or directions in imagination. The picture may be made as an imaginary drawing while the subject reads the problem. The subject may imagine objects on a grid, map, or maneuvering board, or plot with fingers on an imaginary map or ruled surface. Included are instances in which subjects put themselves into the situation and then pictured the pattern of objects around them, e.g., imagining self "on deck" and localizing objects as "ahead," "behind," or "over there."

Deductive.<sup>4</sup> The application of common sense principles of reasoning to the statements in the problem without any "picturing." Also, the reaching of a solution to the problem via one or more relevant principles inferred from the given facts.

Deductive and Spatial. A combination of deductive and spatial, as defined above, in cases in which both were mentioned by judges as clearly active in problem solution to an approximately equal degree.

Three minor categories, in terms of frequency of mention by the judges, were also found as a result of the sorting procedure. They were

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<sup>4</sup> Although such terms as verbal reasoning, numerical reasoning, arithmetical reasoning, and geometrical reasoning are often treated as discrete process categories, the decision was made to include judges' mentions of any one of them in the deductive category on the grounds that a rational process, deductive in nature, is involved in all of them no matter what the tools--verbal, arithmetical, or geometrical. Actually all of these various reasoning terms appeared in a total of 97 out of 1116 cards and were used by four judges out of the six. Of these four, one judge employed them in 62 out of a total of 186 judgments. The remaining 35 instances of the use of these terms were almost equally divided among the other three judges. In all instances where reasoning terms were used by a judge for a particular recorded interview, there were always two or more other judges who described the same material as deductive.

visualization, integration, and verbal ability. Only eleven cards were distributed among all three. An additional category of "no judgment" contained the remaining sixteen cards.

All cards appearing in each category were then sorted according to item number. Then a frequency tabulation was made of the number of times each item was described by the judges as having been solved according to each process category. (See Table 1.) An analysis of the frequency patterns in the cells of Table 1 showed that, when frequency of mention was taken as the criterion, the items fell into the following groupings.

|                                               |                                                 |
|-----------------------------------------------|-------------------------------------------------|
| I. Primarily spatial<br>with some deductive   | Items 1, 4, 5, 9, 10, 11,<br>13, 14, 16, 17, 20 |
| II. Equally spatial and<br>deductive          | Items 2, 3, 6, 12, 19                           |
| III. Primarily deductive<br>with some spatial | Items 7, 15, 18                                 |

Examination of the items in each grouping showed that all of the Group I items, except Item 11, require responses in terms of bearing or course (any one of the eight principal compass points). Item 11 requires a relative speed answer. All items in both Group II and Group III, except Items 18 and 19, require relative speed answers (e.g., Ship A is traveling faster than Ship B). Item 18 requires a distance-in-miles answer and Item 19 requires an answer specifying the course of a ship. It would seem that subjects had responded to items requiring either bearing or course answers in a manner judged to be primarily spatial in nature, whereas items requiring relative speed answers had elicited a mode of response that was judged to be either primarily deductive or equally deductive and spatial. Subjects seemed to emphasize numbers and geometrical concepts to a greater extent when the latter types of item were presented, while items requiring bearing or course answers were very often approached by such methods as "putting myself on deck" and "picturing the situation as it would look."

Finally a comparison was made between the item clusters which had been drawn from a table of tetrachoric intercorrelation coefficients for

TABLE 1  
Number of Descriptions in Each Category by Item

| Category                 | Item |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |  |
|--------------------------|------|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|--|
|                          | 1    | 2  | 3  | 4  | 5  | 6  | 7  | 9  | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |  |
| Spatial                  | 54   | 25 | 23 | 37 | 40 | 24 | 14 | 56 | 40 | 26 | 4  | 10 | 14 | 5  | 30 | 30 | 11 | 9  | 22 |  |
| Deductive                | 0    | 22 | 20 | 14 | 19 | 26 | 36 | 7  | 19 | 4  | 8  | 3  | 1  | 14 | 12 | 1  | 31 | 12 | 8  |  |
| Spatial and<br>Deductive | 0    | 19 | 23 | 0  | 7  | 13 | 9  | 14 | 30 | 26 | 35 | 23 | 25 | 23 | 17 | 28 | 18 | 37 | 11 |  |
| Others                   | 0    | 0  | 0  | 3  | 0  | 3  | 1  | 1  | 1  | 4  | 1  | 6  | 2  | 0  | 1  | 1  | 0  | 2  | 1  |  |
| Total                    | 54   | 66 | 66 | 54 | 66 | 66 | 60 | 78 | 90 | 60 | 48 | 42 | 42 | 42 | 60 | 60 | 60 | 60 | 42 |  |

the purpose of selecting items for presentation, and the item-groupings that emerged as a result of the present analysis. Three of these clusters and the residual items were found to represent a fair approximation of Group I, and the three remaining clusters were found to represent Groups II and III combined. In the former instance, nine of the 12 items in the first composite also appeared in judge-determined Group I. In the latter instance, five of the 11 items in the second composite appeared in judge-determined Groups II and III. Thus, although the drawing of clusters from the table of item-intercorrelations yielded twice as many item-groupings as were determined by the judges, similarities between the outcomes of the two methods became evident.

Since the present method of test analysis depended almost wholly upon the decisions of all judges combined, a study was made of inter-judge consistency. Even though the judges were not given in advance a prepared list of terms upon which to base their descriptions, and even though the judging situation was loosely structured with respect to exactly what the judges should be looking for, there was remarkable consistency among them. There seemed to be almost universal agreement that spatial and deductive processes had been involved in all but few of the reports. The primary differences among judges had to do with whether one or the other of the above-mentioned processes had been more prominent or whether both were about equal in prominence.

A limited investigation was also made of whether certain subjects had displayed a tendency to employ a spatial process, others a deductive process, and still others a combination of the two, no matter what problems had been presented. This resulted in practically negative findings. In no case was such a clear-cut tendency evident; the processes described by the judges were found to vary more as a function of the items than as a function of the subject.

#### Summary.

An interview method was employed to study the abilities measured by the Relative Movement Test. An analysis was made of judges' descriptions of how the subjects solved each of the problems. The findings were as follows:

1. The test seems to provide a measure of spatial and deductive ability. This finding, however, must be interpreted in the light of the additional finding that when the test is administered under normal testing conditions, it is a speeded measure.
2. Three groups of items were identified: (1) those judged to be primarily spatial, (2) those judged to be primarily deductive, and (3) those judged to be both spatial and deductive to an approximately equal extent.
3. Items judged as primarily spatial were generally the ones that required course or bearing answers, whereas those judged as primarily deductive generally required relative speed answers.
4. There was almost universal agreement among judges that spatial and deductive processes were involved in all but few of the reports. Judges differed among themselves with respect to the predominance of spatial and deductive processes.
5. No subject showed a tendency to employ any one of the above-mentioned processes consistently from item to item. Processes were found to vary more as a function of the item than as a function of the subject.

#### Recommendations.

Validity studies of the three types of Relative Movement Test item should be performed, especially if the findings of this study tend to be substantiated by the results of the factorial study now underway. Evidence that the test is a speeded measure when administered under normal testing conditions, suggests that its good predictiveness of success in such schools as tactical radar, fighter director, and sonar may be closely associated with the element of speed. The recommended studies should therefore also provide for a comparison of validities under speeded and essentially unspeeded testing conditions. Such studies would provide the final evidence regarding how best to use Relative Movement Test items in selection and classification of Naval personnel.