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OBSERVER SELF-LOCATION ABILITY AND ITS RELATIONSHIP TO COGNITIVE ORIENTATION SKILLS

John R. Milligan and Raymond O. Waldkoetter

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This report presents research on the ability of observers to locate military targets and to relate that location to their own position by use of military maps. The experimenters used a one-way analysis of variance design in which 30 observers were divided into categories of either high or low self-location abilities (median split) on a previously administered practical exercise in which the observers were required to locate their geographical position in relation to their position on a military map.
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The experimenters then measured the subjects' ability on three tasks: (1) use of a pointing instrument to point the direction to a series of local landmarks familiar to the subjects, (2) use of a pointing instrument to point to a series of cities within the United States, and (3) a visual imagery exercise which required the subjects to follow mentally a complex set of directions and then report their direction at the conclusion of the exercise.

Results revealed statistically significant overall differences between the two groups of observers on all three tasks. Those subjects who scored high on the previous self-location exercise also scored high on the three experimental tasks.

The experimenters conclude that the pointing instrument and visual imagery tasks were successful in distinguishing between subjects who scored well and those who scored low on previous self-location exercises. The experimenters also suggested that the simple pointing instrument and visual imagery tasks may, with further testing, be shown to be effective and low-cost tests to predict which observers will need additional training in self-location skills prior to training in observer skills.

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OBSERVER SELF-LOCATION ABILITY AND ITS RELATIONSHIP TO COGNITIVE ORIENTATION SKILLS

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FOREWORD

The U.S. Army Research Institute for the Behavioral and Social Sciences (ARI) performs research to improve operational practices and procedures in the areas of personnel and management systems, education and training systems, and human factors in system development and operations. One major objective is to determine the relevance, efficiency, and economy of individual performance-oriented skill development and evaluation within the Army. Continued and expanded research in individual training and evaluation is critical for redefinition of the role of service schools--what and how to train in Active, Reserve, and National Guard units--and for effective training by supervisors and commanders. This report evaluates the use of a personnel screening instrument to identify soldiers who would profit from additional preparatory training in self-location and orientation skills to improve their performance in the critical field artillery duty of being a forward observer for indirect fire weapon systems. The effort represents one phase in the exploration of human requirements and limitations for advanced weapon systems and is part of an on-going research effort to assist decision makers in determining training requirements for cost effective training of individuals.

Research on individual skill requirements for the field artillery forward observer is responsive to the requirements of Army Project 2Q163731A770 and to special requirements of the U.S. Army Field Artillery School, Fort Sill, Okla. The work of Donald O. Weitzman, U.S. Army Research Institute, generated an interest and provided a framework for this research. MAJ D. Nemetz and SFC E. Johnson, ARI Field Unit, Fort Sill, assisted in data collection. Material in this report has also been presented at the 20th Military Testing Association Conference, Oklahoma City, Okla., November 1978.

JOSEPH ZEIDNER
Technical Director

OBSERVER SELF-LOCATION ABILITY AND ITS RELATIONSHIP TO COGNITIVE ORIENTATION SKILLS

BRIEF

Requirement:

To investigate selected variables which may be related to the ability of human observers to locate military targets and relate that location to the observers' own position by use of military maps.

Procedure:

The experiment used a correlational and one-way analysis of variance design in which human observers (N = 30) were divided into categories of either high or low self-location abilities (median split) on a previously administered practical exercise in which the observers were required to locate their geographical position in relation to their position on a military map. The experiment then measured the subject's ability on three tasks: (a) use of a pointing instrument to point the direction to a series of local landmarks familiar to the subjects, (b) use of a pointing instrument to point to a series of cities within the United States, and (c) a visual imagery exercise which required the subjects to follow mentally a complex set of directions and then report their direction at the conclusion of the exercise.

Findings:

Results of the research reveal significant overall differences between the two groups of observers categorized on previous self-location exercises. Statistically significant differences between groups on all three tasks were found; those subjects who scored high on the previous self-location exercise also scored high on the three experimental tasks.

Utilization of Findings:

The results indicate that the pointing instrument and visual imagery tasks were successful in distinguishing between subjects who scored well and those who scored low on previous self-location exercises. The experimenters also suggested that the simple pointing instrument and visual imagery task may, with further testing, be shown to be an effective and low-cost test to predict which human observers will need additional training in self-location skills prior to training in observer skills.

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OBSERVER SELF-LOCATION ABILITY AND ITS RELATIONSHIP TO COGNITIVE ORIENTATION SKILLS

INTRODUCTION

The ability of human observers to locate themselves on the earth's surface in relation to other objects or targets on that same surface has widespread military and civilian application. The importance of these applications is easily overlooked because the skill is assumed to exist uniformly among individuals. Self-location and spatial orientation ability is often implicitly assumed to exist at levels common to all individuals in land and sea navigation training even though there is extensive evidence to the contrary (Witkin, 1946; Woodring, 1939). There has been extensive research on spatial orientation related to localized brain damage (Ratcliff & Newcombe, 1973; Hecaen, Tzortzis, & Masure, 1972), sex differences (Cohen, 1976; Maxwell, Croake, & Biddle, 1975; Pellegrini & Empey, 1970), age differences (Howard & Templeton, 1966), and race differences (Osborne & Gregor, 1966), but relatively little research has been specific to self-location or geographical spatial orientation and military map training involving target acquisition for indirect fire weapons. The purpose of the exploratory research reported here is to examine self-location abilities as they relate to cognitive directional orientation, by developing an instrument capable of identifying those who do poorly or do well on such directional tasks.

REVIEW OF LITERATURE

The Army's Human Engineering Laboratory demonstrated the importance of self-location abilities in a field test of the field artillery indirect fire system in the early 1970's (Technical Memorandum 24-70). This field test found that over 50% of the error variance in the indirect fire system was attributed to the forward observer's inability to locate the target or himself in relation to the target within acceptable standards.

Army Training and Evaluation Program (ARTEP) standards allow a maximum error of 250 m in target location. Field tests reveal however, that the average target location error is between 500 to 700 m. This field test, although well designed and well executed, encountered difficulties in controlling nuisance variables which, as the authors noted in that study, may have influenced the reliability of forward observer performance.

The 50% error variance attributed to the forward observer probably overestimates the error variance. There appears, however, little doubt either empirically or logically that the accuracy of the forward observer largely determines the accuracy of the indirect fire weapons.

The rifle marksman's accuracy is affected by the condition of his rifle and the weather conditions, but most importantly by the marksman's aim or perceptual judgment. With indirect fire weapons, however, the crew doing the firing neither sees the target nor calculates adjustments due to weather, distance, etc. These functional tasks are broken down and performed by other team members who, in the case of the forward observer, may be separated by many miles from the actual guns being fired.

The forward observer generally is the only member of the indirect fire team who can actually observe the target being fired upon; he transmits his observations to the fire direction center (FDC) where this information is processed by calculating weather conditions, gun location, type of ammunition being fired, etc. These calculations are then sent to the gun crew in the form of elevation and deflections which will be set on the guns, and the round is fired. The forward observer observes the impact of the rounds fired and transmits corrections to the fire direction center, which in turn recalculates and sends new elevation and deflection information to the gun crew. The essential difference between the perceptual judgment (aiming) used by the rifle marksman and the observing done by a forward observer is in the area of what the researchers call "conceptual associating."

The rifle marksman, once he has established the range of his target and adjusted the sights on his weapon, is faced primarily with a perceptual alignment task in that he must be concerned with the placement of the adjusted and aligned sights upon the target for accuracy. The forward observer on the other hand is faced with the much more complex task of associating a target he can see on a horizontal plane to a military map drawn in the vertical plane. He must be able to analyze the actual terrain from one perspective and to interpolate what that terrain looks like when expressed in symbols and from a different perspective. Thus it is primarily a conceptual task requiring extraction and association of information in a form other than that observed.

Kozlowski and Bryant (1977) studied geographical spatial orientation ability in a series of three experiments in an attempt to investigate further the individual differences in orientation skills reported in the research literature. The first experiment divided human subjects ($N = 45$) into categories of either good sense of direction or bad sense of direction. The subjects were then tested to see if what people say about their sense of direction relates to their actual directional and mapping abilities. The first test consisted of pointing to unseen buildings, map drawing, and pointing to north and nearby cities. The results of this experiment indicated that the better the self-report of sense of direction, the better the orientation performance. Average pointing errors for the combined pointing to unseen buildings and map-drawing tasks were 19.3° ($SD = 9.5$) and 33.2° ($SD = 14.6$) for good and poor sense-of-direction subjects respectively, $t(43) = 3.41$, $p < .01$.

The second experiment in this research, a refinement of the first, included additional independent variables. Subjects were given direction, distance, and time estimation tasks. Results indicated that self-reports of sense of direction and self-reports of distance-estimation ability are highly correlated; and the better the self-reported sense of direction or distance, the smaller the pointing error. The mean pointing error was 10.79° (SD = 5.08) for good sense-of-direction people and 25.71° (SD = 19.53) for poor sense-of-direction people. Actual performance in estimating time or distance failed to correlate with anything; this failure was probably due to lack of variation in the performance data, according to the authors.

The third experiment attempted to answer the question, "How well would self-reports of directional ability be able to predict spatial performance in a novel environment?" A human-sized maze in the form of a section of tunnels underneath a dormitory complex was used to answer this question. The subjects were led through the maze once; they then traveled the maze as a group for four additional trials. After the first, second, third, and fifth trials, subjects were asked to estimate distance traveled and time elapsed, and to point in the direction from the start to the end of the maze. The subjects' performance revealed that by the second trial the good sense-of-direction individuals pointed more accurately than the poor sense-of-direction individuals, $F(1, 30) = 7.09$, $p < .05$.

Estimating the distance of the maze was not a significant main effect for the two groups. However, there was a tendency for poor sense-of-direction people to overestimate their time spent in the tunnel. Interestingly, these differences were not observed on the first trial when subjects were not aware of the purpose of the study and presumably were not attending to the spatial configuration of the maze.

The results of these three experiments led researchers to conclude that the good sense-of-direction people, far from having an extreme facility at orientation (i.e., one that requires little work), appeared to be more active and to put more effort into the tasks.

The Field Artillery School (FAS) at Fort Sill, as a result of the Human Engineering Laboratory's analysis of indirect fire systems previously cited, attempted a further analysis of forward observer performance (Directorate of Evaluation, FAS, 1977). The FAS used a comparison of two data groups: One consisted of data gathered from officer basic classes; the other was composed of artillery officers from field units. The institutional data consisted of target location error, observed fire scores (a written portion and live-fire portion), map-reading scores, and nonverbal tests (Sequential Test of Educational Progress [STEP], and the Lorge Thorndike). Significant correlations were found among all variables except target location and observed-fire score (live-fire portion). Table 1 displays the results of the correlation analysis. These results should be accepted with caution

Table 1

Correlation of Institutional Data

	Step[a]	Lorge Thorndike	Map-reading score	Observed fire score (written)	Observed fire score (practical)	Target[b] location error
Step[a]	r = 1.000	r = .7532 s = .001	r = .1594 s = .001	r = .1168 s = .001	r = .0686 s = .016	r = .1694 s = .001
Lorge Thorndike		r = 1.000	r = .2837 s = .001	r = .2258 s = .001	r = .1647 s = .001	r = .1694 s = .001
Map-reading score			r = 1.000	r = .2897 s = .001	r = .2706 s = .001	r = .1426 s = .001
Observed fire score (written)				r = 1.000	r = .3378 s = .001	r = .1208 s = .001
Observed fire score (practical)					r = 1.000	r = .0579 s = .117

Note. Table is based upon WSTEA Phase 1a data.

[a] Sequential Test of Educational Progress.

[b] N = 735; in all other cases N = 1236; s = significance level.

because large sample sizes such as this (N = 1236) insure that even very small correlations will be statistically significant regardless of the meaningfulness of such correlations.

The field unit data (N = 45) consisted of correlations among self-location, target location, shoot scores, map-reading scores, previous institutional (school) shoot scores, visual acuity, depth perception, nonverbal tests (STEP and Lorge Thorndike), and number of practice missions. Correlational analysis revealed that only two pairs of the variables were correlated at a significant level: the nonverbal tests with self-location and the map-reading scores with field shoot scores. No correlations on the field data were presented in the report. However, a chart showing whether or not the correlation was significant at the .05 level was provided. Although the FAS study failed to show a significant relationship between target-location error and observed fire scores the study concluded that accurate target-location ability was the primary shortcoming of the forward observer.

Based upon these results, the FAS conducted an additional study to analyze the effect of doubling the amount of map-reading instruction given. Comparison between groups of students whose map-reading instruction was doubled and control groups revealed no significant differences between the groups (Directorate of Evaluation, FAS, undated).

The studies reviewed here suggest differences among individuals in spatial orientation, self-location, and target-location abilities. Spatial orientation abilities vary with self-estimates of spatial orientation ability and are related to later performance on orientation tasks. Experience and training may be related to orientation performance, but as yet the relationships have not been clearly demonstrated.

The purpose of the present research was to gather additional empirical data on a limited part of spatial orientation abilities. Particularly, the researchers sought information as to the relationships or differences among individuals on self-location abilities and directional orientation abilities. Significant findings of relationships between these two variables would be an important starting point for larger and more comprehensive research designs.

METHOD

The researchers used a one-way analysis of variance design in which observers (N = 30) were divided into categories of either high or low self-location abilities (median split) on the basis of a previously administered practical exercise in which the observers were required to locate their geographical position in relation to their positions on a military map. The researchers then measured the subjects' ability on three tasks: (a) use of a pointing instrument to point the direction to a series of local landmarks familiar to the subjects, (b) use of a pointing instrument to point to a series of cities within the United States, and (c) a visual imagery exercise which required the subjects to follow mentally a complex set of directions and then report the direction they were facing at the conclusion and at various points of the exercise. Correlational analysis (Pearson product moment) of the three tasks and performance on the previously administered self-location test was completed in an attempt to determine degree of relationship among the tasks.

Subjects

Subjects were 30 male student officers from an officer basic class at the Field Artillery School at Fort Sill. All students had completed forward observer and related subject course areas at the time of testing. Self-location scores (percentage correct) were rank-ordered for all 118 students. Each student was assigned a number, and 15 students were randomly selected from the top half and 15 from the bottom half (median split) of the class. None of the students had been previously assigned to Fort Sill nor had given the Fort Sill area as their home address. Equal exposure to the various locations was assumed by the researchers.

Apparatus and Materials

Two test instruments were used in this research. The first instrument was a 38-inch-diameter circular piece of plywood which could be placed on a flat table. The outer edge of this circle had painted on it the 6400 mils of a military compass in 10-mil increments. Mils were used in this research since this measurement unit is used on military compasses and can be easily converted to degrees. The center of this circle had a rotating post with a 38-inch pointer which could be pointed in any direction and the direction read in mils off the circular base.

Subjects were individually tested in a lighted but enclosed room. They were shown the correct direction to true north with the mils and the pointer correctly oriented. Each subject was then asked to move the pointer as close as possible to the actual direction of six local areas in which the student had frequent contact, i.e., student mail room, post exchange, etc. None of the locations could be observed from the room. Appendix A contains a scoring guide of all locations and their correct directions. The subjects were also required to point the direction to six cities using the pointing instrument, thereby measuring both local and national geographical orientation.

The second test instrument was a mental imagery exercise consisting of a single sheet with square grids covering approximately two-thirds of the page shown to the subjects. Individual subjects were asked to close their eyes and imagine themselves at the top of the series of squares or grids, facing a specified direction. The subjects were then asked to imagine themselves walking along the grid lines in whatever direction and for whatever distance the experimenter instructed, then at various points along this path they were asked which direction they were facing. Each subject completed three of these mental imagery exercises. Instructions with the plotted paths for each of the three exercises are presented in Appendix B to this paper.

Procedure

Subjects were randomly selected for each of the two groups as previously described and were tested individually. The researcher briefly described the study to each subject and obtained informed consent. Then each subject was taken into the room that contained the pointing instrument. The room was lighted and the window curtains drawn closed. There was no attempt to eliminate directional visual cues within the room. The subject was shown the operation of the pointing instrument, and then the instrument pointer was placed on true north and the subject asked to point to the previously described locations. Appendix C contains a listing of raw score data for each subject on each test.

RESULTS

Scores for pointing error (local and distant cities), visual imagery, and self-location were subjected to correlational analysis. These results are presented in Table 2. As can be seen from an examination of these results, the strongest correlation is between the visual imagery scores and the self-location scores.

Local Points

One-way analysis of variance was used to evaluate the group differences in scores for pointing to six local areas with which the subjects had daily to weekly contact. Absolute error scores measured in mils from the actual azimuth measured from true north were used in this analysis as the dependent variable. Transformation of scores was not required, since underlying assumptions of the one-way ANOVA were met. Group assignment was the independent variable: Group 1 consisted of subjects who had scored above the median on a field self-location test, and Group 2 consisted of those who had scored below the median on the same self-location test. Table 3 presents the results of this analysis.

As expected, Group 1 (high self-location scores) performed significantly ($p < .04$) letter than Group 2 (low self-location scores) on pointing to local points. Table 4 presents the means, standard deviations, and errors for these two groups. As can be seen from these tables, the relative difference is rather small when the mils are

Table 2

Correlation of Pointing Errors, Visual Imagery, and Self-Location Scores

	1	2	3	4
1. Self location	1.00	-.40 s = .014	-.32 s = .041	.53 s = .001
2. Pointing error (local)		1.00	.14 s = .234	-.29 s = .063
3. Pointing error (distant cities)			1.00	-.36 s = .024
4. Visual imagery				1.00

Note. N = 30; s = significance level.

Table 3

Analysis of Variance of Mean Error in Pointing to Local Points for Groups 1 and 2

Source	SS	df	MS	F
Between groups[a] treatment	34884	1	34884	4.60*
Within groups[a] error	212431	28	7587	
Total	247315	29		

Note. N = 30; 15 per group. Numbers rounded to nearest whole number. Unit of measure is mils (6400 mils = 360°).

[a]Group 1 = subjects scoring above median on self-location test.
Group 2 = subjects scoring below median on self-location test.

*$p < .04$.

converted to degrees (17.6^{o} error for Group 1 and 22^{o} error for Group 2). Although group differences are relatively small, the data suggest that the ability to point to unseen locations (i.e., mental mapping ability) is useful in differentiating between high and low scores in self-location tasks.

Table 4

Means, Standard Deviations, and Errors for Groups on Pointing to Local Points

Group[a]	Mean	SD	Standard error
1	264	67	17.32
2	332	103	26.68
Total	298	92	16.86

Note. N = 30; 15 per group. Numbers rounded to nearest whole number. Unit of measure is mils (6400 mils = 360^{o}).

[a]Group 1 = subjects scoring above median on self-location test.
Group 2 = subjects scoring below median on self-location test.

Distant Cities

One-way analysis of variance as previously described in the analysis of local points was used to analyze the differences in groups for pointing to distant cities. The results of this analysis are presented in Tables 5 and 6. As in the previous analysis, significant differences were obtained between groups ($p < .03$) on pointing to distant cities. Again, examination of the results of the analysis of variance and the means, standard deviation, and errors reveals the pointing instrument was effective in differentiating between groups.

Visual Imagery

The third analysis, like the first and second, revealed significant differences ($p < .002$) between the two groups on the visual imagery task. As can be seen from an examination of Tables 7 and 8, the visual imagery task appears to be a more reliable indicator of group differences.

Table 5

Analysis of Variance of Mean Error in Pointing to Distant Cities for Groups 1 and 2

Source	SS	df	MS	F
Between groups[a]				
treatment	150946	1	150946	5.43*
Within groups[a]				
error	778886	28	27817	
Total	929832	29		

Note. N = 30; 15 per group. Numbers rounded to nearest whole number. Unit of measure is in mils (6400 mils = 360°).

[a]Group 1 = subjects scoring above median on self-location test. Group 2 = subjects scoring below median on self-location test.

*$p < .03$.

Table 6

Means, Standard Deviations, and Errors for Groups on Pointing to Distant Cities

Group[a]	Mean	SD	Standard error
1	366	83	21.49
2	507	221	56.98
Total	437	179	32.69

Note. N = 30; 15 per group. Numbers rounded to nearest whole number. Unit of measure is in mils (6400 mils = 360°).

[a]Group 1 = subjects scoring above median on self-location test. Group 2 = subjects scoring below median on self-location test.

Table 7

Analysis of Variance of Scores Obtained on Visual Imagery Test for Groups 1 and 2

Source	SS	df	MS	F
Between groups[a]				
treatment	2484	1	2484	11.73*
Within groups[a]				
error	5933	28	212	
Total	8417	29		

Note. N = 30; 15 per group. Numbers rounded to nearest whole number. Scores represent percent correct.

[a]Group 1 = subjects scoring above median on self-location test.
Group 2 = subjects scoring below median on self-location test.

*$p < .002$.

Table 8

Means, Standard Deviations, and Errors for Groups on Visual Imagery Test

Group[a]	Mean	SD	Standard error
1	90	12	3.04
2	72	17	4.36
Total	81	17	3.11

Note. N = 30; 15 per group. Numbers rounded to nearest whole number. Scores represent percent correct.

[a]Group 1 = subjects scoring above median on self-location test.
Group 2 = subjects scoring below median on self-location test.

CONCLUSION

This research examined the relation between self-location abilities and certain spatial cognition skills which enable an individual to point to unseen locations and to maintain directional orientation using visual imagery. The results of the preliminary research have demonstrated that differences between high scores and low scores on a self-location test can be differentiated by use of a simple pointing instrument and visual imagery task. These results are promising and suggest potential value for an expanded investigation in which a multivariate statistical design will allow for greater control of variables and analysis of their contributions to performance in self-location and target location abilities.

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APPENDIX A

POINTING INSTRUMENT SCORING GUIDE

Location name	Location azimuth (mils)
1. Officers club	5855
2. Main PX	5075
3. Ft. Sill Blvd exit	3610
4. Key Gate	2490
5. Mail room	1825
6. CF department	4900
7. Oklahoma City	0710
8. New Orleans	2150
9. Dallas	2550
10. Houston	2670
11. Kansas City, Mo.	0620
12. Denver	5610

APPENDIX B

VISUAL IMAGERY EXERCISE

<u>Narrative Instructions--Grid 1</u>

1. Graphic representation: See attached sheet.

2. Scoring procedure: Score one point for each correct direction given by the subject. Ask the subject for his direction at each place indicated in the narrative.

3. Narration:

    a. Close your eyes and imagine yourself facing south on the grid previously shown to you.

    b. Proceed two blocks south. Stop.

    c. Turn 90° left, now proceed two blocks and stop.

    What direction are you now facing? (Correct answer is east)

    d. Now turn left 90° and proceed two blocks. Stop.

    e. Turn left 90° and proceed two blocks. Stop.

    What direction are you now facing? (Correct answer is west)

    If the subject correctly answers both questions, score 2 for this sample.

4. Now give the subject a blank grid and ask him to draw the directions he followed in this example.

5. Ask the subject for any questions to clarify the procedure.

6. Proceed to the next exercise if the subject understands the directions.

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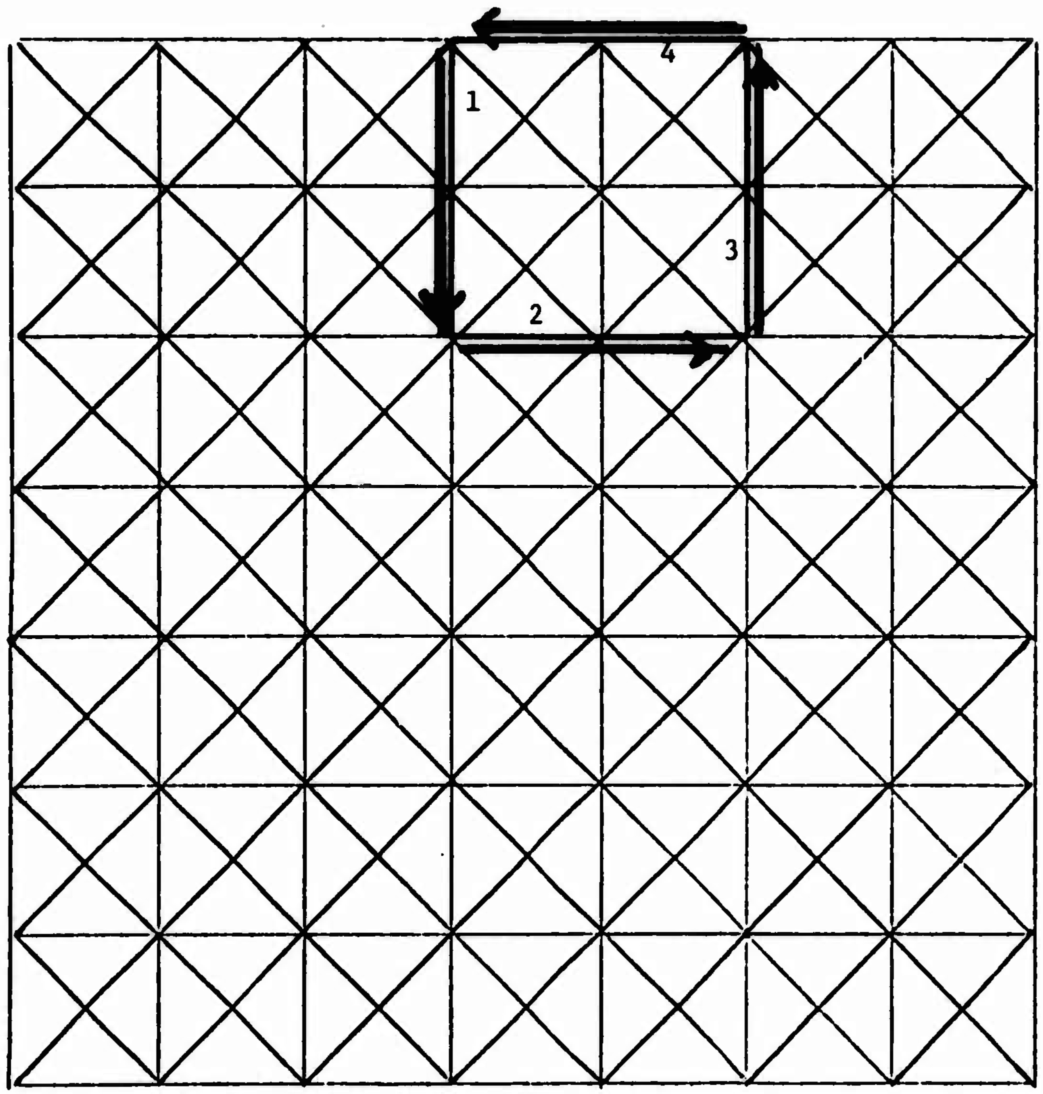

Figure B-1. Visual imagery exercise--Grid 1.

Narrative Instructions--Grid 2

1. Close your eyes. Imagine yourself facing south on the grid you were just shown.

2. Proceed one block and stop.

3. Turn 90° left, walk one block and stop.

4. Turn 90° right, walk one block and stop.

   What direction are you now facing? (A3, south)

5. Turn right 90°, proceed one block and stop.

6. Turn right again 90°, proceed one block and stop.

   What direction are you now facing? (A5, north)

7. Turn right 90°, proceed one block and stop.

   What direction are you facing? (A6, east)

8. Turn left 90°, proceed one block and stop.

9. Turn left 90°, proceed one block and stop.

   What direction are you now facing? (A8, west)

10. On this blank grid page draw the route you have been following.

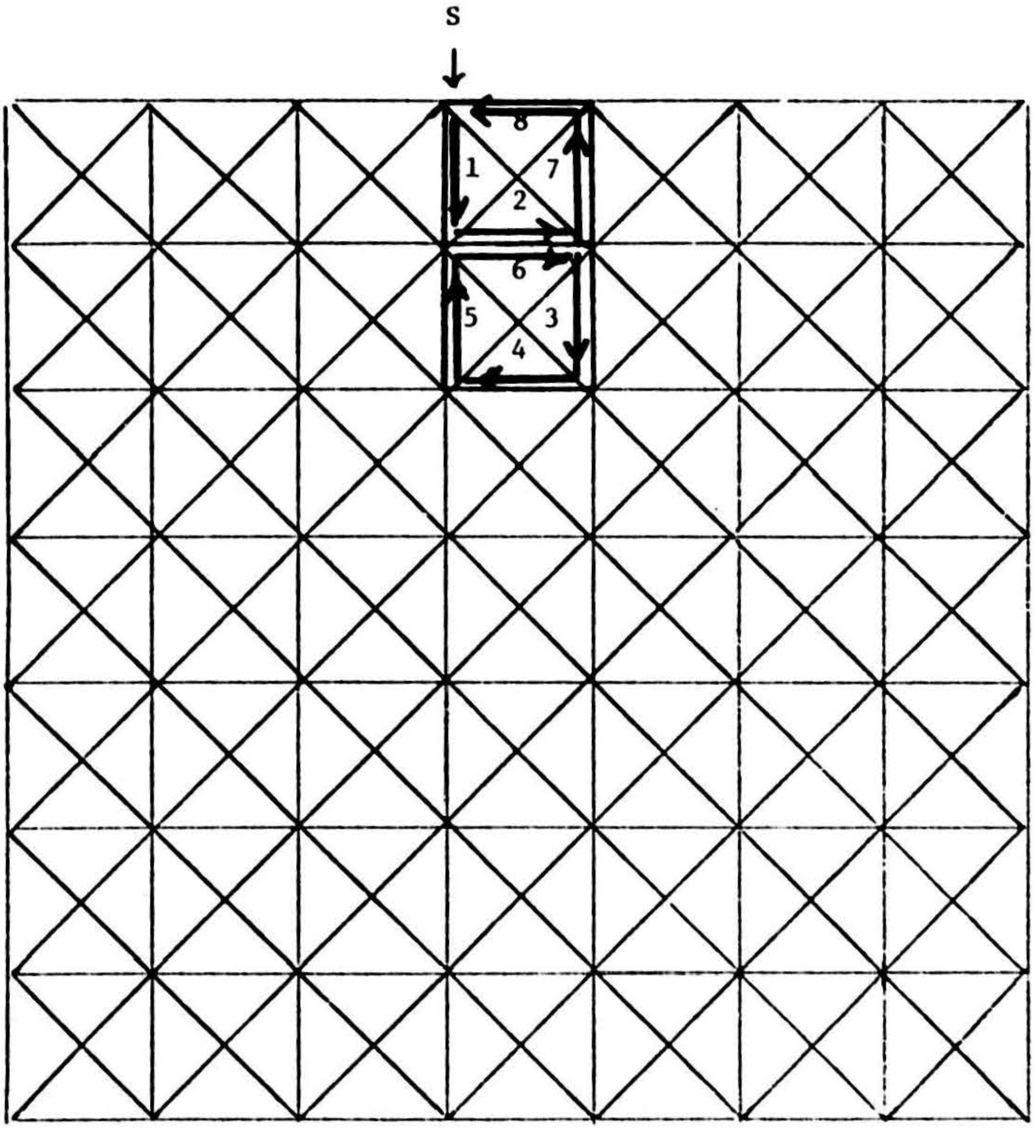

Figure B-2. Visual imagery exercise--Grid 2.

<u>Narrative Instructions--Grid 3</u>

1. Close your eyes. Imagine yourself facing east on the grid you were just shown.

2. Proceed two blocks and stop.

3. Turn right 90^{o}, now turn 45^{o} more to the right, proceed two blocks and stop.

   What direction are you now facing? (A2, southwest)

4. Turn left 90^{o}, now turn 45^{o} more to the left, proceed two blocks and stop.

   What direction are you now facing? (A3, east)

5. Turn left 180^{o}, then turn right 45^{o}.

   What direction are you now facing? (A4, northwest)

6. Proceed two blocks in this direction and stop. Turn left 45^{o}.

   What direction are you now facing? (west)

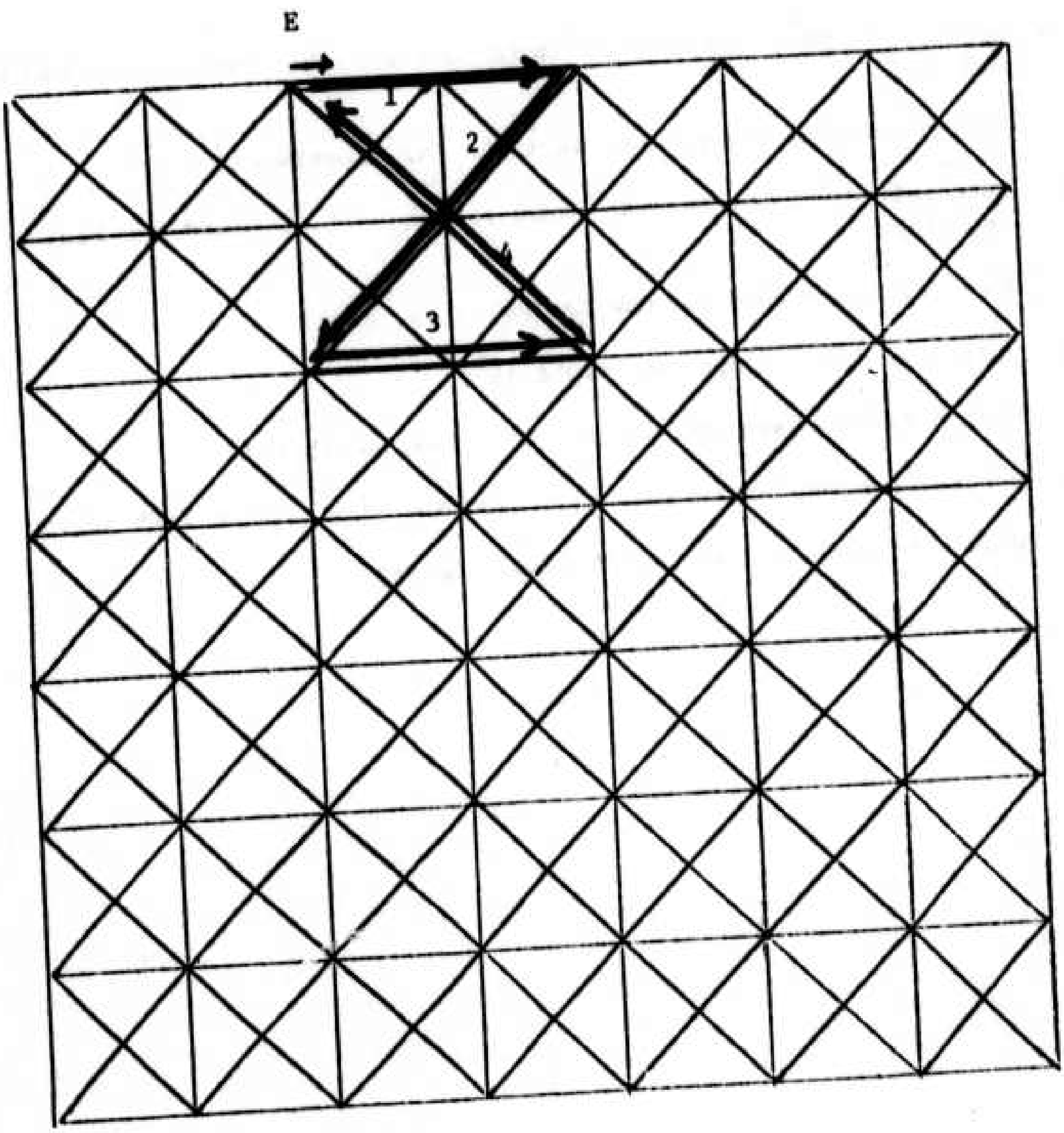

Figure B-3. Visual imagery exercise--Grid 3.

APPENDIX C

LISTING OF INDIVIDUAL SCORE DATA

Group 1[a]				
Subject number	Self-location score (%)	Mean of local points pointing errors (mils)	Mean of distant cities pointing errors (mils)	Visual imagery score (%)
1	98	231	435	70
2	98	265	252	90
3	99	144	360	99
4	98	294	252	99
5	99	306	317	99
6	93	246	457	70
7	95	354	445	99
8	96	224	227	90
9	99	228	400	99
10	99	171	307	99
11	95	273	442	99
12	98	414	468	80
13	99	288	405	70
14	95	233	300	99
15	95	291	423	90

[a]Group 1 = upper half of median split based on self-location scores.

Group 2 [b]				
Subject number	Self-location score (%)	Mean of local points pointing errors (mils)	Mean of distant cities pointing errors (mils)	Visual imagery score (%)
16	71	592	318	80
17	76	313	428	80
18	79	483	562	40
19	85	233	407	60
20	89	318	460	80
21	88	291	502	90
22	86	284	930	70
23	74	261	960	90
24	70	343	325	99
25	71	431	698	50
26	84	319	240	80
27	79	271	390	70
28	70	244	648	50
29	73	391	500	80
30	65	211	250	60

[b] Group 2 = lower half of median split based on self-location scores.

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