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Harold W. Gordon
Martin P. Charns, School of Management, Boston U
Barbara Garamoni

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Visuospatial skill usually attributed to the right cerebral hemisphere is positively and significantly related to measures of job complexity in a human resources department of a bank. Subjects having the more complex jobs performed better on visuospatial skills. The group as a whole, however, performed better on verbal/sequential skills, as might be expected for the type of job. The results suggest that complex jobs attract individuals with greater visuospatial skills regardless of the cognitive profile expected for the particular job type.

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WESTERN PSYCHIATRIC INSTITUTE AND CLINIC

JOB COMPLEXITY AND COGNITIVE PERFORMANCE IN BANK PERSONNEL

Harold W. Gordon

Martin P. Charns

Barbara W. Garamoni

Western Psychiatric Institute and Clinic
University of Pittsburgh University.
&
School of Management
Boston University

September, 1984

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3811 O'HARA STREET, PITTSBURGH, PA. 15213

ABSTRACT

Visuospatial skill usually attributed to the right cerebral hemisphere is positively and significantly related to measures of job complexity in a human resources department of a bank. Subjects having the more complex jobs performed better on visuospatial skills. The group as a whole, however, performed better on verbal/sequential skills, as might be expected for the type of job. The results suggest that complex jobs attract individuals with greater visuospatial skills regardless of the cognitive profile expected for the particular job type.

Table of Contents

Job Complexity and Cognitive Performance in Bank Personnel

Performance on visuospatial skills associated with specialized function of the right hemisphere has been shown to predict success in combat pilots (Gordon et al, 1981). The notion that visuospatial functions might be better performed by artists, and verbal functions might be better performed by lawyers is generally borne out in testing (Arndt and Berger, 1978) even though individuals in these diverse occupations do not show left/right differences in brain activation (Dumas and Morgan, 1975, Arndt and Berger, 1978). Unfortunately, in spite of the empirical support for some obvious occupations, more subtle implications of cognitive preference in most occupations have to be validated in their own right. This study is a first attempt in this direction.

Thinking processes associated with the right hemisphere are characterized as "diffuse" (Semmes, 1968), "global" and "parallel" (Cohen, 1973). We have hypothesized that for the business world, such broad thinking would be associated with jobs that are comprised of interconnected duties or tasks. "Interconnectedness" implies that performance of one task that influences or is mutually dependent upon performance of another task. A "global thinking style" should be useful for keeping track of many different projects and ideas, as well as their mutual interactions, at one time. To test this hypothesis, an objective scale of job complexity was developed (Charns and Schaeffer, 1983) to which assessment of cognitive abilities (Gordon, 1983) may be compared. Individuals who hold the most complex jobs would be expected to have greater ability in tasks associated with the right hemisphere, such as 3-dimensional perception and other spatial manipulations. Their particular duties should have less importance, theoretically, than the number and complexity of these duties. Exceptions would be specialized jobs such as sculptors, jet pilots, and perhaps computer programmers, because the cognitive skill neded for the type of job is likely to confound the complexity issue.

For this study, it was convenient to select the Human Resources Department of a local bank in which there were clerical staff and secretaries as well as middle managers. An overall bias toward left hemisphere, verbal/sequential functioning might be expected in the department as a whole, but the more complex jobs should be held by individuals who have greater visuospatial ability.

Method

Subjects

Twenty-three employees of a Human Resources department at a major bank in the Pittsburgh area were tested with the Cognitive Laterality Battery (CLB) to determine the cognitive profiles of job holders. In addition, job descriptions and job analyses were completed on 4 male and 16 female employees for a final sample of 20.

Instruments

The Cognitive Laterality Battery. The Battery consists of eight tests and, along with instructions, is presented on 35mm slides together with audio cassettes. The subjects observe or listen to the stimulus presentation and respond on special answer forms passed out for each test. The tests had been chosen to reflect the visuospatial and verbal/sequential functioning of the right and left hemispheres respectively. Factor analyses on the normative population confirmed the qualitative, orthogonal differences between the function types.

The tests were administered in a fixed order alternating according to factor type. The following is a description of the tests in the order presented:

(1) Serial Sounds: A total of 12 sequences of 4, 5, 6 and 7 familiar sounds (e.g., baby, bugle, rooster, bird, telephone, etc.) were played from a pre-recorded tape. The subject's task was to write the items in the same sequential order. The onsets of each sound in the sequence were spaced at 2-second intervals. The subject waited for a start signal at the end of the sequence before the answer. Scoring was based on the number of items correctly reported in sequence whether or not the whole sequence was correct.

(2) Localization: A photographic slide containing a black "x" within a black frame on a white background was flashed on a screen for 3 seconds. The subject had a similar frame on the answer sheet and marked with a pencil the location of the "x" within it. There were 24 slides arranged in pseudorandom order counterbalanced such that the same number of "x's" appeared in each of the four quadrants. Subject's score was the total error in millimeters accumulated over all trials. (This was the only test in which a high score represented a poor performance).

(3) Serial Numbers: A total of 9 sequences of 4, 5,...9 single digit numbers were presented at a rate of 1 per second. At the end of each sequence the subject was required to write the sequence in the same order as presented. The scoring was the same as Serial Sounds in which partial credit was given to correct fragments of sequences even if the whole sequence was not correct.

(4) Orientation: (Adapted from Shepard and Metzler, 1971). The stimulus was a slide of 3, three-dimensional, S-shaped constructions

of 10 stacked cubes. Two constructions were identical but rotated in space around a vertical axis. The third was the same as the other two but appeared as the mirror image. The subject was given 15 seconds to select the two constructions that were alike. There were 24 trials.

(5) Word Production, Letters: The subject was given one minute to write as many words as possible, beginning with a given letter of the alphabet. The subject's score was the total of three attempts, each time with a different letter.

(6) Word Production, Categories: The subject listed as many animal and food names as possible. One minute was allowed for each category. The subject's score was the total of the two categories.

(7) Form Completion (Closure Speed): (Adapted from Thurstone and Jeffreys, 1966; French, Ekstrom, and Price, 1963). The stimulus was a slide containing 6 incomplete silhouette drawings of common objects or scenes appearing white on a blue background. The items were selected from two similar tests and chosen to be as culture-free as possible. The task was to identify and describe, in a word or two, each of the 6 drawings. Forty-five seconds were allowed for each slide and answers were written on special answer sheets. Six slides were presented for a total of 36 items.

(8) Touching Blocks: (MacQuarrie, 1953). The stimulus was a slide of one large cube construction made up of 8-10 stacked rectangular blocks. The blocks were stacked such that anywhere from 2 to 8 blocks were adjacent to (touching) any one block. For each stimulus slide, 5 of the blocks were numbered and the subject was given 45 seconds to indicate the number of touching blocks for each of the numbered blocks. There were 6 slides for a total of 30 items.

Analysis of performance on the Cognitive Laterality Battery. Standard scores were calculated on the basis of means and standard deviations of 250 adults drawn in part from a non-college population and in part from an undergraduate and graduate student population. The scores were derived separately for males and females. Mean scores for the two main factors were calculated by averaging the standard scores for the visuospatial tests (called A after "Appositional" (Bogen et al., 1972) and verbal/sequential tests (called P after "Propositional"). A cognitive profile called the Cognitive Laterality Quotient (CLQ) is defined by the difference between the two averaged scores: $CLQ = A-P$. For a "normal" subject, $CLQ = A=P=0$, by definition since all are linear combinations of standard scores. When $CLQ>0$, the visuospatial tests are performed better; when $CLQ<0$, the verbal/sequential tests are performed better.

The CLQ is the dependent variable that defines the relative processing efficiency of brain functions as determined by the CLB subtests. A measure of overall ability can also be obtained by averaging the two averaged cognitive measures: Cognitive Performance Quotient, $CPQ = (A+P)/2$.

Job Description and Job Analyses. In order to determine the number of elements contained in a specific job and the nature (and number) of interconnections between the elements, the following steps were taken:

(1) Job Description Rating: A job description was first obtained for each employee from the supervisor. In an interview, this supervisor defined the various elements that make up a particular job, e.g., among the elements in combat piloting are (a) attaining proper altitude, and (b) attaining proper air speed. The supervisor was then asked to rate each job element on its importance within the

total job using a scale of 1 to 7 (1= of minor importance to job; 7 = of extreme importance to job). A standardized description sheet was used (see Appendix A).

(2) Supervisors were then asked to fill in a triangular matrix (see Appendix B) defining the "interconnections" between job elements. Interconnections were defined as:

0 = No connection between job elements; i.e., Element X has no effect on performing Element Y.

1 = Sequential dependence of job elements; i.e., Element X influences Element Y but not the reverse (X-->Y).

2 = Reciprocal dependence of job elements; i.e., Element X influences Element Y and, at a subsequent time, Element Y influences Element X (X$\underset{<--}{\overset{-->}{}}$Y).

3 = Simultaneous interdependence; i.e., Element X and Element Y influence each other dynamically (X<-->Y).

(3) Performance Rating: In the final step, the supervisors were asked to rate the job holder's performance for each element. This was accomplished by placing an "x" along a line in the location that best described performance. End points of the line were defined as "Worst Possible Performance" and "Best Possible Performance." A score was obtained by measuring the distance in cm. from the left endpoint. (see Appendix C). An overall performance rating was then obtained for the job as a whole using the same line scale.

Measures

Two types of complexity measures were developed from the job description data obtained from supervisors. The first type was job *scope*, computed as the number of elements per job. The second type was *interconnectedness*, for which there were the different degrees described above: "simultaneous", "sequential", and "reciprocal," as well as "none" (no interconnections). It was intended that the number of higher order interconnections between elements would provide a first approximation to the actual job complexity. The more elements, the larger the job; but also the greater the degree of interconnectedness, the more complex the job. The variables, then, were the numbers of Simultaneous, Reciprocal, Sequential and Null connections.

Since the number of interconnected pairs of a job is dependent on the job scope, (the total number of job elements), jobs with a larger scope would have more pairs of elements and therefore more complex elements just by virtue of their size. Accordingly, Indices of Complexity were defined by the ratio of each degree of interconnectedness to all possible interconnected pairs. For example, the Index of Simultaneous Complexity would be the number of simultaneous interconnections (i.e., number of 3's) divided by the number of all possible connections (i.e., pairs of elements) (0's + 1's + 2's + 3's).

The number of interconnections also does not capture the qualitative difference between two characteristically different types of jobs having the same numbers of interconnections: 1) jobs where one or two elements were highly interconnected with other elements, compared to 2) jobs where interconnections were distributed more homogeneously across all possible pairs of elements. To assess this difference, an Index of Complexity for Complex Elements (ICCE), was created. For this Index, the 4 most complex elements were selected. Complexity was defined by computing the ratio of Simultaneous, Reciprocal and Sequential interconnections to the total number of possible interconnections in each element (1's + 2's + 3's)/(0's + 1's + 2's + 3's). To get an ICCE the 4 highest ratios were averaged and compared to a similar average ratio for all the elements together. An ICCE of 1.0 would by "perfect" homogeneity--the 4 most complex elements are just as complex as the rest. Jobs in which some of the elements were highly complex would have ratios greater than 1.0.

Finally, none of the above measures account for the fact that some elements are more important for job performance than other elements as determined by supervisor ratings. Accordingly, an Index of Complexity for Important Elements (ICIE) was calculated in the same way as the ICCE except that the average of the 4 most important elements were taken as the numerator of the Index ratio rather than the 4 most complex. The 2 indices would be identical if the most important elements were also the most complex. There is also the possibility that the Index of Complexity for Important Elements could be less than 1.0.

Results

Visuospatial skill is positively related to job scope -- the total number of job elements -- of the job ($r = 0.49$, $p<0.05$) (See Table 1). This means that job holders with the highest ability to perceive and remember points in space, visualize in 3-dimensions, and imagine completed shapes were also those that had acquired the jobs with the greatest number of different tasks. By contrast, verbal/sequential skills were not related to the number of job elements ($r = 0.02$). In other words, job holders had attained more complex jobs whether or not they were verbally fluent or had good sequential memories for sounds or numbers.

-- Place Table 1 about here --

The same significant relationship between visuospatial skills maintained for the number of the most complex (Simultaneous) interconnections, but not for the other interconnections. For the Simultaneous connections, $r = 0.43$ $p<.06$); for the Reciprocal, Sequential and Null connections, r's were less than 0.20. However, this result may be artifactually related to the somewhat smaller number of Reciprocal and Sequential interconnections. There were 50%-100% more Simultaneous connections than Reciprocal or Sequential, while the number of Null connections was about twice that of the Simultaneous connections.

The unequal number of interconnections suggests a problem. There is no assurance that supervisors were able to distinguish clearly between the 3 types of higher-level interconnections. Not only did the job elements themselves have ambiguous relationships but the criteria were not always easily applicable. If the data are reanalyzed such that the Reciprocal, or the Reciprocal and Sequential, interconnections are included together with the Simultaneous interconnections, the interaction between two job elements would be dichotomized to be either "complex" or "null". This redefinition of complexity improved the correlation between visuospatial skills and the number of interconnected job elements. (See Table 1) The correlations with Simultaneous + Reciprocal, and with Simultaneous + Reciprocal + Sequential were $r = .43$ and $r = 0.48$, respectively. By contrast, correlations between the number of Null connections and visuospatial skills was small: $r = 0.15$.

The significant correlations with visuospatial skill were also found for the number of complex connections of the 4 most important job elements. The ranking for importance of each had been performed previously by the supervisors. The correlations between the numbers of complex interconnections (i.e., number of 1's + 2's + 3's) and visuospatial skill were 0.54, 0.63, 0.60, and 0.54, for the first 4 important elements, respectively. (See Table 2) The correlations between visuospatial skills and the number of Null interconnections averaged about -0.12. This means that for the most important elements of the job, the relationship between visuospatial skills and complexity is even stronger than for the measures of complexity of the job as a whole. For all these connections, the correlations with the verbal/sequential skills were still small.

-- Place Table 2 about here --

Another way to measure complexity is by an Index of combined Complexity defined by the ratio of complex interconnections to the total number of interconnections: (1's + 2's + 3's)/(0's + 1's + 2's + 3's). The larger the IC, the greater the number of job elements that have complex interactions. The converse is that jobs with a low IC are those which have a lot of duties (elements) that are not connected with one another.

Correlations between visuospatial skills and the IC's are positive but not significant as they had been between visuospatial function and the total numbers of complex interactions. (See Table 3) However, there were positive and significant correlations between the IC's and verbal/sequential skills where there had been no correlation between numbers of connections and verbal/sequential skills in the previous analyses. Apparently, the Indices of Complexity were highly correlated with overall performance (visuospatial plus verbal/sequential skills) on the Cognitive Laterality Battery.

--Place Table 3 about here--

There was no relationship between specialized cognitive performance and jobs that had a concentration of complex rather than a homogeneous mix of complex elements. Nor was there a relationship between specialized cognitive function and jobs in which the more complex elements were the more important elements. This simply means that jobs with "hetergeneous" complexity defined by the Index of Complexity for Complex Elements (ICCE) or by the Index of Complexity for Important Elements (ICIE) were not particularly related to specialized cognitive function.

Discussion

The significant relationship between visuospatial skills and job complexity encourages the view that specialized cognitive functions of the brain are related to success in managerial positions with respect to the complexity of the duties. This conclusion is based on the assumption that in the population studied, individuals were hired or promoted to their particular jobs because of recognition of their skills by management. This assumption is not unreasonable since performance ratings were invariably high suggesting satisfaction by management that their choices had been accurate. (The performance ratings had been made confidentially without benefit or detriment to the employee.)

A second possibility cannot be ruled out. More individuals who already had preference for right hemisphere skills could have been attracted to the more managerial positions or complex job duties. In other words, it is possible there was a self selection process. However, by whatever method -- undoubtedly subjective -- the persons most skilled in locating points in space or imagining objects in three dimensions were hired, promoted or chose jobs requiring many different tasks, especially those that were mutually interactive.

At first glance, it would seem unusual for an employer to hire or promote someone based on their better ability to visualize cube configurations than to remember sequences. A closer look at the theoretical basis of such a decision lends some support to the idea. The results of this study suggest that the common factor of performing well both on visuospatial tasks and in complex jobs is that both require specialized cognitive functioning associated with the right cerebral hemisphere. The positive correlations between the cognitive functions and job complexity are the first step in validating the use of a cognitive profile for management decisions in efficacious placement of employees.

The missing element in this study is further validation by performance ratings. The difficulty seemed to be in the range of scores. Most subjects were rated in the upper third of the performance scale; the lowest was at the 60% line. Given this restricted range, statistical analyses are less likely to detect significant relationships which might be evident over a broader spectrum of performance ratings. As it turned out, the person with the greatest mismatch between cognitive profile and job complexity received the second lowest performance rating. The highest rated persons did not necessarily have the best cognitive/complexity match, however; nor did other low-rated individuals have serious mismatches. Another statistical limitation concerns the small number of subjects at the extremes of performance ratings. Further studies of this kind will augment the sample size and increase the power of significance tests. Finally, the performance appraisals undoubtedly are based on a number of personality factors, which would be unrelated to the complexity assessed by our techniques. Again, with relatively few subjects in this study, it is not too surprising those data were not more contributory.

The concept of "hemisphericity" has become popular in some circles. Individuals are defined along a continuum from favoring verbal/sequential skills normally associated with the left hemisphere to visuospatial skills normally associated with the right hemisphere. The popularity stems from the idea that a person who is "right brained" -- performs better on tasks associated with the right hemisphere -- might be using only half of the brain. Self-help courses thrive on the notion that such a person would be helped by training the other, presumably unused, side of the brain. Validation that "right brained" people use only the right brain, or that one brain half could be trained, is simply lacking. Even studies which show that individuals such as artists, engineers, and lawyers do have specialized cognitive preferences, also demonstrate that there is no difference in asymmetry of electrical brain activation (Arndt and Berger, 1978; Dumas and Morgan, 1975).

What, then, is valid about specialized brain skills and performance in daily endeavors? For one thing, there is face validity in the observations that those with good performance on visuospatial tasks are often artists, architects, and so forth, while those with good verbal skills are lawyers, accountants, and such. More specifically, studies have shown that good combat pilots do have the superior visuospatial skills expected of them (Gordon, 1982). Even children who have chosen special interests in model building favor visuospatial skills, while those who favor creative writing have relatively better verbal/sequential skills (Gordon, 1983). What is not valid is that the specialized abilities of these people do not necessarily imply that one hemisphere is more active than the other. The whole brain contributes to the performance of tasks. The implication is that some people are more efficient in performing specialized tasks associated with one hemisphere than the other. Accordingly, the concern of this study was not <u>where</u> in the brain a task is performed but, rather, how well performance on a specialized task is predictive of job success. If the specialized tasks are chosen to be the tasks that are related to special processing of the right or left hemisphere, then we have achieved a link from the rather nebulous concept of job duties and job performance to clearer and more valid notions of cognitive function of the human brain. The results have given an initial "green light" that such a link may be made, but we must proceed with caution until further confirmation is forthcoming.

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Table 1. Pearson Correlations Between Job Complexity and Cognitive Function

	Cognitive Laterality Measures			
	A	P	CLQ	CPQ
Job Complexity Measure				
SCOPE	.49**	-.02	.47**	.29
Number of Interconnections				
Simultaneous	.43*	-.02	.41*	.25
Reciprocal	.18	.02	.15	.12
Sequential	.19	.11	.08	.18
Simultaneous and Reciprocal	.43*	-.01	.40*	.26
Simultaneous, Reciprocal and Sequential	.48**	.02	.42*	.31
Null	.15	-.23	.33	-.04

*p < .10

**p < .05

Table 2. Pearson Correlations Between Complexity of Important Items and Cognitive Function

	Cognitive Laterality Measures			
Number of Interconnections	A	P	CLQ	CPQ
SIMULTANEOUS				
First most important	.41*	.11	.29	.32
Second " "	.48**	.06	.39*	.33
Third " "	.48**	-.00	.44*	.30
Fourth " "	.46**	.02	.41*	.29
RECIPROCAL				
First " "	.16	.28	-.10	.27
Second " "	.22	.24	-.01	.28
Third " "	.13	.38	-.21	.30
Fourth " "	.19	.18	.02	.23
SEQUENTIAL				
First " "	.19	-.18	.32	.01
Second " "	.15	.06	.08	.13
Third " "	.21	-.09	.27	.07
Fourth " "	.18	.23	-.04	.24
SIMULTANEOUS & RECIPROCAL				
First " "	.45**	.23	.21	.41*
Second " "	.55**	.22	.32	.47**
Third " "	.51**	.23	.27	.45**
Fourth " "	.47**	.12	.33	.36
SIMULTANEOUS, RECIPROCAL AND SEQUENTIAL				
First " "	.54**	.19	.33	.45*
Second " "	.63***	.25	.36	.54**
Third " "	.60***	.20	.37	.49**
Fourth " "	.53**	.20	.32	.45**
NULL				
First " "	-.01	-.27	.22	-.16
Second " "	-.14	-.36	.18	-.30
Third " "	-.12	-.33	.17	-.27
Fourth " "	-.11	-.34	.19	-.26

* $p < .10$; ** $p < .05$; *** $p < .01$

Table 3. Pearson Correlations Between Index of Complexity and Cognitive Function

	Cognitive Laterality Measures			
	A	P	CLQ	CPQ
Indices of Complexity (IC)				
Simultaneous	.34	.26	.09	.36
Reciprocal	.05	.27	.19	.19
Sequential	.11	.25	-.11	.22
Simultaneous and Reciprocal	.36	.41*	-.03	.46**
Simultaneous, Reciprocal and Sequential	.33	.45**	-.10	.47**
Null	-.41*	-.50**	.06	-.55**

* $p < .10$

** $p < .05$

JOB TITLE: ____________________

Appendix A

JOB ELEMENTS

(1) List below the job elements required to perform the specific job listed above. Be as specific as possible.

(2) Rate each job element according to its importance to the total job using the Rating Scale to the right.

JOB ELEMENTS	RATING SCALE						
	1 = Very minor	2 = Low	3 = Slightly below average	4 = Average	5 = Slightly above average	6 = High	7 = Extreme
1.	1	2	3	4	5	6	7
2.	1	2	3	4	5	6	7
3.	1	2	3	4	5	6	7
4.	1	2	3	4	5	6	7
5.	1	2	3	4	5	6	7
6.	1	2	3	4	5	6	7
7.	1	2	3	4	5	6	7
8.	1	2	3	4	5	6	7

Appendix B

Fill in diagram defining interconnections between job components listed on previous pages. Interconnections are defined as:

0 = No connections between elements; i.e., Element X has no effect on performing Element Y.
1 = Sequential dependence; i.e., Element X influences Element Y but not the reverse. (X→Y)
2 = Reciprocal dependence; i.e., Element X influences Element Y and, at a subsequent time, Element Y influences Element X. (X⇄Y)
3 = Simultaneous interdependence; Element X and Element Y influence each other dynamically. (X↔Y).

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1																			
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JOB PERFORMANCE RATING

Appendix C

JOB TITLE: ______________________

JOB HOLDER: ______________________

SUPERVISOR: ______________________

INSTRUCTIONS: Please rate the above Job Holder by putting an "X" along the line in the location that best describes his/her performance on each individual job element.

1.	Worst Possible Performance	Average Performance	Best Possible Performance
2.	Worst Possible Performance	Average Performance	Best Possible Performance
3.	Worst Possible Performance	Average Performance	Best Possible Performance
4.	Worst Possible Performance	Average Performance	Best Possible Performance
5.	Worst Possible Performance	Average Performance	Best Possible Performance
6.	Worst Possible Performance	Average Performance	Best Possible Performance
7.	Worst Possible Performance	Average Performance	Best Possible Performance
8.	Worst Possible Performance	Average Performance	Best Possible Performance

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Washington, D. C. 20301

Dr. Dennis Leedom
Office of the Deputy Under Secretary
of Defense (C^3I)
Pentagon
Washington, D. C. 20301

Department of the Navy

Engineering Psychology Group
Office of Naval Research
Code 442EP
800 N. Quincy St.
Arlington, VA 22217 (3 cys.)

Aviation & Aerospace Technology
Programs
Code 210
Office of Naval Research
800 North Quincy Street
Arlington, VA 22217

CDR. Paul E. Girard
Code 252
Office of Naval Research
800 North Quincy Street
Arlington, VA 22217

Physiology Program
Office of Naval Research
Code 441NP
800 North Quincy Street
Arlington, VA 22217

Dr. Edward H. Huff
Man-Vehicle Systems Research Division
NASA Ames Research Center
Moffett Field, CA 94035

Department of the Navy

Dr. Andrew Rechnitzer
Office of the Chief of Naval
Operations, OP952F
Naval Oceanography Division
Washington, D.C. 20350

Manpower, Personnel & Training
Programs
Code 270
Office of Naval Research
800 North Quincy Street
Arlington, VA 22217

Mathematics Group
Code 411-MA
Office of Naval Research
800 North Quincy Street
Arlington, VA 22217

Statistics and Probability Group
Code 411-S&P
Office of Naval Research
800 North Quincy Street
Arlington, VA 22217

Information Sciences Division
Code 433
Office of Naval Research
800 North Quincy Street
Arlington, VA 22217

CDR Kent S. Hull
Helicopter/VTOL Human Factors Office
NASA-Ames Research Center MS 239-21
Moffett Field, CA 94035

Dr. Carl E. Englund
Naval Health Research Center
Environmental Physiology
P.O. Box 85122
San Diego, CA 92138

Department of the Navy

Special Assistant for Marine
Corps Matters
Code 100M
Office of Naval Research
800 North Quincy Street
Arlington, VA 22217

Mr. R. Lawson
ONR Detachment
1030 East Green Street
Pasadena, CA 91106

CDR James Offutt
Office of the Secretary of Defense
Strategic Defense Initiative Organization
Washington, D.C. 20301-7100

Director
Naval Research Laboratory
Technical Information Division
Code 2627
Washington, D.C. 20375

Dr. Michael Melich
Communications Sciences Division
Code 7500
NaVAL Research Laboratory
Washington, D.C. 23075

Dr. J. S. Lawson
Naval Electronic Systems Command
NELEX-06T
Washington, D. C. 20360

Dr. Neil McAlister
Office of Chief of Naval Operations
Command and Control
OP-094H
Washington, D. C. 20350

Naval Training Equipment Center
ATTN: Technical Library
Orlando, FL 32813
Naval Research Laboratory
Washington, D.C. 20375

Department of the Navy

Dr. Robert G. Smith
Office of the Chief of Naval
Operations, OP987H
Personnel Logistics Plans
Washington, D. C. 20350

Combat Control Systems Department
Code 35
Naval Underwater Systems Center
Newport, RI 02840

Human Factors Department
Code N-71
Naval Training Equipment Center
Orlando, FL 32813

Dr. Alfred F. Smode
Training Analysis and Evalustion
Group
Naval Training & Equipment Center
Orlando, FL 32813

Human Factors Engineering
Code 8231
Naval Ocean Systems Center
San Diego, CA 92152

Dr. Gary Poock
Operations Research Department
Naval Postgraduate School
Monterey, CA 93940

Dean of Research Administration
Naval Postgraduate School
Monterey, CA 93940

Mr. H. Talkington
Engineering & Computer Science
Code 09
Naval Ocean Systems Center
San Diego, CA 92152

Department of the Navy

Mr. Paul Heckman
Naval Ocean Systems Center
San Diego, CA 92152

Dr. Ross Pepper
Naval Ocean Systems Center
Hawaii Laboratory
P. O. Box 997
Kailua, HI 96734

Dr. A. L. Slafkosky
Scientific Advisor
Commandant of the Marine Corps
Code RD-1
Washington, D. C. 20380

Dr. L. Chmura
Naval Research Laboratory
Code 7592
Computer Sciences & Systems
Washington, D. C. 20375

Office of the Chief of Naval
Operations (OP-115)
Washington, D.C. 20350

Professor Douglas E. Hunter
Defense Intelligence College
Washington, D.C. 20374

CDR C. Hutchins
Code 55
Naval Postgraduate School
Monterey, CA 93940

Human Factors Technology Administrator
Office of Naval Technology
Code MAT 0722
800 N. Quincy Street
Arlington, VA 22217

CDR Tom Jones
Naval Air Systems Command
Human Factors Programs
NAVAIR 330J
Washington, D. C. 20361

Department of the Navy

Commander
Naval Air Systems Command
Crew Station Design
NAVAIR 5313
Washington, D. C. 20361

Mr. Philip Andrews
Naval Sea Systems Command
NAVSEA 61R
Washington, D. C. 20362

Commander
Naval Electronics Systems Command
Human Factors Engineering Branch
Code 81323
Washington, D. C. 20360

Mr. Herb Marks
Naval Surface Weapons Center
NSWC/DL
Code N-32
Dahlgren, VA 22448

Mr. Milon Essoglou
Naval Facilities Engineering Command
R&D Plans and Programs
Code 03T
Hoffman Building II
Alexandria, VA 22332

CAPT Robert Biersner
Naval Biodynamics Laboratory
Michoud Station
Box 29407
New Orleans, LA 70189

Dr. Arthur Bachrach
Behavioral Sciences Department
Naval Medical Research Institute
Bethesda, MD 20014

Dr. George Moeller
Human Factors Engineering Branch
Submarine Medical Research Lab
Naval Submarine Base
Groton, CT 06340

Department of the Navy

Head
Aerospace Psychology Department
Code L5
Naval Aerospace Medical Research Lab
Pensacola, FL 32508

Commanding Officer
Naval Health Research Center
San Diego, CA 92152

Dr. Jerry Tobias
Auditory Research Branch
Submarine Medical Research Lab
Naval Submarine Base
Groton, CT 06340

Navy Personnel Research and
Development Center
Planning & Appraisal Division
San Diego, CA 92152

Dr. Robert Blanchard
Navy Personnel Research and
Development Center
Command and Support Systems
San Diego, CA 92152

CDR J. Funaro
Human Factors Engineering Division
Naval Air Development Center
Warminster, PA 18974

Mr. Stephen Merriman
Human Factors Engineering Division
Naval Air Development Center
Warminster, PA 18974

Mr. Jeffrey Grossman
Human Factors Branch
Code 3152
Naval Weapons Center
China Lake, CA 93555

Human Factors Engineering Branch
Code 4023
Pacific Missile Test Center
Point Mugu, CA 93042

Department of the Navy

Dean of the Academic Departments
U. S. Naval Academy
Annapolis, MD 21402

Dr. W. Moroney
Naval Air Development Center
Code 602
Warminster, PA 18974

Human Factor Engineering Branch
Naval Ship Research and Development
Center, Annapolis Division
Annapolis, MD 21402

Dr. Harry Crisp
Code N 51
Combat Systems Department
Naval Surface Weapons Center
Dahlgren, VA 22448

Mr. John Quirk
Naval Coastal Systems Laboratory
Code 712
Panama City, FL 32401

Department of the Army

Dr. Edgar M. Johnson
Technical Director
U. S. Army Research Institute
5001 Eisenhower Avenue
Alexandria, VA 22333

Technical Director
U. S. Army Human Engineering Labs
Aberdeen Proving Ground, MD 21005

Director, Organizations and
Systems Research Laboratory
U. S. Army Research Institute
5001 Eisenhower Avenue
Alexandria, VA 22333

Mr. J. Barber
HQS, Department of the Army
DAPE-MBR
Washington, D.C. 20310

Department of the Air Force

Dr. Kenneth R. Boff
AF AMRL/HE
Wright-Patterson AFB, OH 45433

U.S. Air Force Office of
Scientific Research
Life Science Directorate, NL
Bolling Air Force Base
Washington, D.C. 20332

AFHRL/LRS TDC
Attn: Susan Ewing
Wright-Patterson AFB, OH 45433

Chief, Systems Engineering Branch
Human Engineering Division
USAF AMRL/HES
Wright-Patterson AFB, OH 45433

Dr. Earl Alluisi
Chief Scientist
AFHRL/CCN
Brooks Air Force Base, TX 78235

Dr. R. K. Dismukes
Associate Director for Life Sciences
AFOSR
Bolling AFB
Washington, D.C. 20332

Foreign Addresses

Dr. Kenneth Gardner
Applied Psychology Unit
Admiralty Marine Tech. Estab.
Teddington, Middlesex TW11 OLN
England

Human Factors
P.O. Box 1085
Station B
Rexdale, Ontario
Canada M9V 2B3

Foreign Addresses

Dr. A. D. Baddeley
Director, Applied Psychology Unit
Medical Research Council
15 Chaucer Road
Cambridge, CB2 2EF England

Other Government Agencies

Defense Technical Information Center
Cameron Station, Bldg. 5
Alexandria, VA 22314 (12 copies)

Dr. Clinton Kelly
Defense Advanced Research Projects
Agency
1400 Wilson Blvd.
Arlington, VA 22209

Dr. M. C. Montemerlo
Human Factors & Simulation
Technology, RTE-6
NASA HQS
Washington, D.C. 20546

Other Organizations

Ms. Denise Benel
Essex Corporation
333 N. Fairfax Street
Alexandria, VA 22314

Dr. Andrew P. Sage
First American Prof. of Info. Tech.
Assoc. V.P. for Academic Affairs
George Mason University
4400 University Drive
Fairfax, VA 22030

Other Organizations

Dr. Robert R. Mackie
Human Factors Research Division
Canyon Research Group
5775 Dawson Avenue
Goleta, CA 93017

Dr. Amos Tversky
Dept. of Psychology
Stanford University
Stanford, CA 94305

Dr. H. McI. Parsons
Essex Corporation
333 N. Fairfax St.
Alexandria, VA 22314

Dr. Jesse Orlansky
Institute for Defense Analyses
1801 N. Beauregard Street
Alexandria, VA 22043

Dr. J. O. Chinnis, Jr.
Decision Science Consortium, Inc.
7700 Leesburg Pike
Suite 421
Falls Church, VA 22043

Dr. T. B. Sheridan
Dept. of Mechanical Engineering
Massachusetts Institute of Technology
Cambridge, MA 02139

Dr. Paul E. Lehner
PAR Technology Corp.
Seneca Plaza, Route 5
New Hartford, NY 13413

Dr. Paul Slovic
Decision Research
1201 Oak Street
Eugene, OR 97401

Other Organizations

Dr. Harry Snyder
Dept. of Industrial Engineering
Virginia Polytechnic Institute
and State University
Blacksburg, VA 24061

Dr. Stanley Deutsch
NAS-National Research Council (COHF)
2101 Constitution Avenue, N.W.
Washington, D.C. 20418

Dr. Amos Freedy
Perceptronics, Inc.
6271 Variel Avenue
Woodland Hills, CA 91364

Dr. Robert Fox
Dept. of Psychology
Vanderbilt University
Nashville, TN 37240

Dr. Meredith P. Crawford
American Psychological Association
Office of Educational Affairs
1200 17th Street, N.W.
Washington, D.C. 20036

Dr. Deborah Boehm-Davis
Dept. of Psychology
George Mason University
4400 University Drive
Fairfax, VA 22030

Dr. Howard E. Clark
NAS-NRC
Commission on Engrg. & Tech. Systems
2101 Constitution Ave., N.W.
Washington, D.C. 20418

Other Organizations

Dr. Charles Gettys
Department of Psychology
University of Oklahoma
455 West Lindsey
Norman, OK 73069

Dr. Kenneth Hammond
Institute of Behavioral Science
University of Colorado
Boulder, CO 80309

Dr. James H. Howard, Jr.
Department of Psychology
Catholic University
Washington, D. C. 20064

Dr. William Howell
Department of Psychology
Rice University
Houston, TX 77001

Dr. Christopher Wickens
Department of Psychology
University of Illinois
Urbana, IL 61801

Mr. Edward M. Connelly
Performance Measurement
Associates, Inc.
1909 Hull Road
Vienna, VA 22180

Professor Michael Athans
Room 35-406
Massachusetts Institute of
Technology
Cambridge, MA 02139

Dr. Edward R. Jones
Chief, Human Factors Engineering
McDonnell-Douglas Astronautics Co.
St. Louis Division
Box 516
St. Louis, MO 63166

Other Organizations

Dr. Babur M. Pulat
Department of Industrial Engineering
North Carolina A&T State University
Greensboro, NC 27411

Dr. Lola Lopes
Information Sciences Division
Department of Psychology
University of Wisconsin
Madison, WI 53706

National Security Agency
ATTN: N-32, Marie Goldberg
9800 Savage Road
Ft. Meade, MD 20722

Dr. Stanley N. Roscoe
New Mexico State University
Box 5095
Las Cruces, NM 88003

Mr. Joseph G. Wohl
Alphatech, Inc.
3 New England Executive Park
Burlington, MA 01803

Dr. Marvin Cohen
Decision Science Consortium, Inc.
Suite 721
7700 Leesburg Pike
Falls Church, VA 22043

Dr. Robert Wherry
Analytics, Inc.
2500 Maryland Road
Willow Grove, PA 19090

Dr. William R. Uttal
Institute for Social Research
University of Michigan
Ann Arbor, MI 48109

Dr. William B. Rouse
School of Industrial and Systems
Engineering
Georgia Institute of Technology
Atlanta, GA 30332

Other Organizations

Dr. Richard Pew
Bolt Beranek & Newman, Inc.
50 Moulton Street
Cambridge, MA 02238

Dr. Hillel Einhorn
Graduate School of Business
University of Chicago
1101 E. 58th Street
Chicago, IL 60637

Dr. Douglas Towne
University of Southern California
Behavioral Technology Lab
3716 S. Hope Street
Los Angeles, CA 90007

Dr. David J. Getty
Bolt Beranek & Newman, Inc.
50 Moulton street
Cambridge, MA 02238

Dr. John Payne
Graduate School of Business
Administration
Duke University
Durham, NC 27706

Dr. Baruch Fischhoff
Decision Research
1201 Oak Street
Eugene, OR 97401

Dr. Alan Morse
Intelligent Software Systems Inc.
160 Old Farm Road
Amherst, MA 01002

Dr. J. Miller
Florida Institute of Oceanography
University of South Florida
St. Petersburg, FL 33701