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ABSTRACT

The 21 summaries of research programs, funded by the United States Army Research Institute (ARI) for the Behavioral and Social Sciences which are presented are grouped in five broad topic areas: computer-based systems; information processing; learning, memory and transfer; human relations; and related issues and trends. Papers presented include: (1) "Research and Development on Training and Personnel in the Department of Defense," by Jesse Orlansky; (2) "Uses of Computer-Assisted Instruction in Developing and Maintaining Psychomotor Skills," by J. Berkhout; (3) "The Design of User-Computer Graphic Conversations," by J. Foley and V. Wallace; (4) "Computerized Adaptive Achievement and Ability Testing," by G. Kingsbury and D. Weiss; (5) "Human Information Processing of Real-World Scenes," by I. Biederman; (6) "Human Performance at Night and in Darkness," by E. Galanter; (7) "Memory Processes in the Recall and Use of Spatial Cartographic Information," by S. Kerst and J. Howard; (8) "Training Expert Decision Makers to Ignore Nondiagnostic Information," by J. Shanteau; (9) "Analysis of Reward Functions in Learning," by M. H. Marx; (10) "The Perceptual Organization of Behavior," by D. Newtson; (11) "Individual Differences in Visual-Motor Organization," by J. Notterman; (12) "Cognitive Learning Strategies and Study Skills to Improve Retention," by C. E. Weinstein; (13) "Investigations of Cognitive Control Processes in Conditioning," by D. D. Wickens; (14) "Organizational Structure and Leadership Factors as Determinants of Small Group Performance," by A. H. Harris; (15) "A Task-Based Framework for Understanding and Improving Group Performance," by D. M. Herold; (16) "A Study of Leader Behavior in the Effective Management of Organizational Crises," by T. W. Milburn; (17) "Decisions about Causes of Poor Performance," by T. R. Mitchell; (18) "Organizational Tolerance of Innovation: A Comparative Study of Military Organizations," by W. R. Adkins; (19) "Effective Use of Managerial Ability and Knowledge--Beyond Selection and Training," by F. E. Fiedler; (20) "Social and Psychological Variables in Organizational Innovation," by R. H. Davis; and (21) "Concepts and Methods in the Study of the All-Volunteer Army," by C. Moskos. Biographical information on the authors is also provided. (ESR)

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COLLOQUIUM ON SELECTED TOPICS IN BEHAVIORAL SCIENCE BASIC RESEARCH

Glenda Y. Nogami, Paul A. Gade, Joel Schendel and Beatrice Farr

Editors

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

In 1980, the US Army Research Institute for the Behavioral and Social Sciences (ARI) sponsored a colloquium of selected topics from the Basic Research program. Twenty-one principal investigators on research funded by ARI presented their findings. The proceedings are grouped into five broad topic areas: computer-based systems; information processing; learning, memory and transfer; human relations; and issues and trends.

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Basic Research

ARI Research Reports and Technical Reports are intended for sponsors of R&D tasks and for other research and military agencies. Any findings ready for implementation at the time of publication are presented in the last part of the Brief. Upon completion of a major phase of the task, formal recommendations for official action normally are conveyed to appropriate military agencies by briefing or Disposition Form.

COPA is the acronym for the Committee on Professional Activities within ARI. The responsibilities of COPA are two-fold: (1) to advise the Technical Director of ARI upon professional matters of general interest to the professional staff, and (2) to act on matters affecting the professional welfare of the staff. COPA represents all junior and mid-management level professional staff (GS-09 to GS-13). One COPA representative and one alternate are elected from each Technical Area and Support Function. COPA representatives meet monthly to discuss concerns and issues raised by the staff members.

One of the issues raised at a COPA meeting was the lack of information about the work being done under the basic research program. Because most research within ARI tends to be applied and focused, scientists within ARI are not always aware of new developments in other fields. Information about the basic research program was seen to be important in keeping staff members aware of the most recent "state of the art." In response to this concern, COPA (with the support of both the director of the Basic Research program and the Technical Director) sponsored a colloquium on selected topics in behavioral science research.

The Colloquium was held at ARI from 23 to 25 April 1980. Twenty principal investigators on Basic Research contracts were invited to attend and present their research findings. The presentations were separated into five topic areas: These areas were: Computer-Based Systems, Information Processing, Learning, Memory and Transfer, Leadership and Performance, and Issues and Trends. This report contains an overview of each session written by the session chairperson and the principal investigator's synopsis of his/her research.

Edgar M. Johnson

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ARI Organization and Research Structure

ARI traces its lineage to Army research and application during World War I and is a direct descendant of such activities during World War II. In response to increasingly complex research needs in the behavioral and social sciences by the Army ARI has grown accordingly, and in October 1972, it was designated as the Army's developing agency for research and development efforts in the behavioral and social sciences. A field operating agency of the Deputy Chief of Staff for Personnel (DCSPER), it is made up of civilian scientists-including psychologists, statisticians, and computer specialists, military personnel, and appropriate administrative and support personnel. The Institute is problem and product-oriented; responding to, and working with agencies and commands throughout the Army. In addition to the headquarters and research center in Alexandria, Virginia, there are the field units, each located at an Army installation, nine in the United States and one in Europe, affiliated with the local Army command.

ARI within the Army Research Community

ARI is the primary research organization in the Army for the human component, excluding physiological and system specific research. As the human component is involved in all facets of the Army activity and systems at various stages of development, the ARI research program is multi-faceted. Most Army research and development is hardware oriented, following a more or less progressive sequence, starting with basic research (designated as 6.1 funding) concerned with research on theory, new technology or to test concepts, progressing into exploratory development (designated as 6.2 funding) which takes the basic research results and prototypes of alternate system components or concepts to test their applicability; into advanced development (designated as 6.3 funding) concerned with pilot testing sub-systems or total systems. As the ARI program is part of the overall Army research program, its efforts are designated by the same phraseology (i.e. basic research, exploratory development, and advanced development). However, because it deals with the human component, the analogy to the hardware development cycle may be less than perfect, as much of the research, even at the exploratory and advanced development stages is non-system specific. In addition, to a much greater degree than hardware development, the process is iterative, with research in a particular area of research moving up and down the research spectrum as conditions dictate. One possible example would be basic research on skill acquisition and measurement of Army skills, and then selection and testing of an applied expansion of the concept as part of a performance testing system. The progression, then, is to start with a need, develop and test concepts relevant to meeting that need in the abstract (in a laboratory), test them in an Army context, and finally test them as part of the system for which they are intended.

The placement of basic research in the same organization as exploratory and advanced development research is unusual within the Department of Defense. This is a great advantage to both the basic research investigator and the ARI scientist having technical oversight responsibility. It increases the flow of basic research findings into applied research and also the exchange of ideas between ARI and the basic research institutions. As almost all 6.1, basic research, is performed through means of contractual efforts with organizations or institutions external to ARI, the practical benefit to the Army of the liaison to exploratory and advanced development through the scientists doing the work is quite important.

Program Structure. ARI's current program lies in the following four areas: personnel and manpower; education and training; training devices and simulation; and human factors in training and operational systems. As these titles imply, there is much ARI research that interrelates across program lines. There is also much of it which cuts across the boundaries of applications in systems.

The key point is that ARI research is along programmatic lines, i.e., manpower, training, etc., which cut across specific system considerations. It is not project based as is hardware, nor system engineered in the same sense as hardware projects are. The technology base is less rigidly defined than that for hardware, yet is taxed for systems equally, if not more, complex. Research and development requests are often entered at the 6.3, advanced development level, requiring research to develop concepts or sub-systems for the programmed applications. The result is a need to maintain research continuity through basic and exploratory development research balanced by a measure of flexibility. In basic efforts this means work among the areas above continues, but particular emphases among them may change from year to year as may be the relative weight of given areas.

KEYNOTE SPEAKER

Foreword

Dr. Orlansky addresses the issue of cost-effective evaluation and use of Department of Defense (DoD) sponsored research results. Dr. Orlansky uses two evaluation studies of the cost effectiveness of training innovations as examples of how research has helped to solve people-related problems in the DoD. As part of his description of these training research projects, Dr. Orlansky provides us with an excellent overview of the purpose and function of DoD sponsored research and just how the whole process works.

RESEARCH AND DEVELOPMENT ON TRAINING AND PERSONNEL IN THE DEPARTMENT OF DEFENSE

Jesse Orlansky
Institute for Defense Analyses

Introduction

Dr. Arden L. Bement, Deputy Under Secretary of Defense Research and Engineering (Research and Advanced Technology) told Congress early in March 1980 that the continuing objective of the Science and Technology Program of the Department of Defense is to "maintain a level of technological supremacy which enables the United States to develop, acquire and maintain military capabilities needed for our national security" (Bement, 1980). Three specific goals for this program in Fiscal Year 1981 are:

1. Provide real growth in the Technology Base (e.g., precision-guided smart weapons that are more autonomous and more independent of weather and battlefield environments).

2. Exploit the use of Advanced Technology Developments (6.3A) for more effective transition of technology to military systems (e.g., passive infra-red search and track, Ada common programming language, active and passive seekers for anti-armor munitions, on-board oxygen generating system for forward-based aircraft).

3. Expedite a selected set of technologies which are of prime importance for protecting technological lead time (e.g., very high speed integrated circuits, directed energy, advanced materials, manufacturing technology and embedded computer software technology).

Dr. Bement also told Congress that Training and Simulation Technology is one of 13 selected areas in which there are major technical programs for Fiscal Year 1981. Major efforts will be made to improve the technology of simulators, computer-based instruction, computer-based voice recognition and synthesis for training purposes, highly realistic, free play field exercises using laser devices for shooting, scoring and immediate feedback for training and the use of simulators for hands-on maintenance training; there will also be increased efforts to adapt computer-based arcade games and hand-held calculators to military training purposes (Bement, 1980, II-1 to II-6; III-18 to III-20).

The basic research programs (6.1) of the three services in Training and Personnel Systems Technology for FY 1981, which support the work being reported at this meeting, are shown in Table 1. These programs increased by $2.7 M or about 17 percent compared to FY 1980; this is about the average increase for all Department of Defense research programs this year; (this increase is about double the increase shown by the National Science Foundation in the Behavioral and Social Sciences this year).

Table 1

Basic Research (6.1) in Training and
Personnel Systems Technology Department of Defense, FY 1981

Army	$4.0 M
Navy	7.3
Air Force	7.3
	$18.6 M

The Department of Defense is not a research agency, per se, such as the National Science Foundation or the National Institutes of Health. Rather, it supports basic research and applied research in order to improve its operations. Table 2 shows funds for the basic and applied efforts of the Military Services in the area of training and personnel in FY 1981. The main point to note is that more funds are needed to develop and evaluate the uses to which new ideas can be put (6.2-6.4) than to create the new ideas themselves (6.1). You could say either that the creation of new ideas and knowledge is not a major expense or that the investment in new ideas leads to large additional costs to develop and evaluate their results. Even greater costs than those shown here would be required for the procurement, operation and maintenance, over their life times, of new systems that come into existence as a result of some of the new ideas that are generated by basic research.

Table 2

Research and Development Funds for Training and
Personnel Systems Technology, Department of Defense, FY 1981

Activity	Army	Navy	Air Force	TOTAL Dollars	TOTAL Percent
Research (6.1)	$ 4.0 M	$ 7.3 M	$ 7.3 M	$ 18.6 M	8.2
Exploratory Development (6.2)	20.2	12.2	25.2	57.6	25.4
Advanced Development (6.3)	18.4	26.8	4.9	50.1	22.1
Engineering Development (6.4)	11.8	75.7	13.2	100.7	44.4
TOTAL	$54.4 M	$122.0 M	$50.6 M	$227.0 M	100.1%

Table 3 shows the major objectives of the funds allocated to basic and applied research in the area of training and personnel. These objectives are stated by the Department of Defense when it requests funds from Congress to support this work. About half of these funds go to simulation and training devices. Total funds for training and personnel have inceased over the past few years and their distribution within these objective areas has remained relatively stable.

Table 3

Objectives of the Training and Personnel Systems Technology Program (6.1-6.4) of the Department of Defense

Major Objectives	FY 78	FY 79	FY 80	
Human Factors	$ 28.2 M	$ 25.5 M	$ 33.1 M	18.5%
Simulation & Training Devices	60.3	65.1	96.2	53.7
Education & Training	24.1	26.7	24.1	13.5
Manpower & Personnel	10.1	18.3	25.5	14.3
TOTAL	$122.7 M	$135.4 M	$178.9 M	100.0%

Let us turn next to the importance of personnel in the DoD's budget. There are 2,059,000 military and 990,000 civilian personnel in the DoD, FY 1981. The costs of manpower in FY 1981 are $77.1 billion or 49 percent of the total military budget ($158.7 billion) (Brown, 1980, p. 263). About 350,000 new recruits are added each year; about 30 percent of these recruits fail to complete their initial enlistment (i.e., are lost within 3 years - FY 1978 data); only about 37 percent reenlist for a second term (Military Manpower Training Report, 1979).

Enlisted personnel are lost at various points during a recruit's first term of enlistment as shown in Table 4. Consideration of these data should suggest problems of interest to research personnel concerned with, e.g., selection, training, manpower, personnel management and morale; these appear to be the areas in which different problems appear to be dominant as a recruit progresses during his first term.

Table 4

Accession, Attrition and Re-enlistment Rates
in the Department of Defense, 1980

	Months of Service	Army	Navy	Marine Corps	Air Force	DoD Total
ACCESSIONS (projection FY 1980)	--	156,000	87,700	39,800	69,000	353,200
ATTRITION						
(actual FY 78+FY 79)	0-6 mos.	12%	12%	13%	10%	12%
(actual FY 78+FY 79)	0-12	18	15	17	15	16
(projection FY 1979)	0-36	31	30	30	27	30
	1ST RE-ENLISTMENT (2-6 yrs)	43%	37%	19%	38%	37% (63,800)
RE-ENLISTMENT (actual FY 1979)	CAREERIST (2nd re-enlistment or more)	66	62	52	81	68% (117,300)
	TOTAL	56	47	33	60	53% (181,300)

SOURCE: AVF data base, ASD (MRA&L), 20 March 1980.

The Department of Defense spends about $7.6 billion each year for various types of individual training (see Table 5). To a large extent, this is what it costs to train the new people who are added to the Services each year. However, these are only the costs of training personnel at schools; these costs are known because they appear in various budgets. The costs of other types of training are not included here, e.g., on-the-job training, advanced flight training for pilots, transition flight training, crew and unit training for weapons, platforms and support systems, field exercises and so on. These types of training activities occur in operational commands after an individual has completed school training. These costs of training within operational commands are clearly very large but there is no way at present to determine their actual magnitudes.

Table 5

NUMBER OF STUDENTS AND COST OF VARIOUS TYPES OF INDIVIDUAL TRAINING, FY 1980

Type of Training	Number of Students (Input, 000)	Cost $
Recruit	326	652 M
One-station unit training (Army)	115	274 M
Officer acquisition	4	254 M
Specialized skill	429	1,838 M
Undergraduate flight	6	828 M
Professional development education	31	298 M
Medical training	16	205 M
Support, mgmt, travel	----	3,268 M
		$7,617 M

Let me turn now to the problem of evaluating the products of research. The general question is whether it is possible to assess what research on training and personnel can do or has done to help solve problems related to people in the Department of Defense. I cannot do this for all types of research on training and personnel. However, I can describe what was done in two specific areas of military training.

The genesis of this effort was a report of the Defense Science Board (1976), an advisory group to the Under Secretary of Defense for Research and Engineering. The report found that research and development had produced important innovations in training and that military training appeared to be effective. However, very little had been done to determine the cost and effectiveness of these innovations in training. As a result of this finding, studies were performed on the cost-effectiveness of flight simulators and the cost-effectiveness of computer-based instruction in military training (Orlansky and String, 1977, 1979). These studies will be summarized briefly because of their inherent interest and because of the clues they provide for future research in training, simulation and training devices.

Flight Simulator Studies

The Military Services have markedly increased their use of flight simulators since the oil boycott of 1973 and the large increases in the cost of fuel for aircraft. It turns out the flight simulators are much less expensive to use than are aircraft. Based on some data we were able to collect, the median variable operating cost of simulators is about 12 percent of that for the same aircraft (see Figure 1). The real question, therefore, is how simulators compare to aircraft when used for training pilots.

In order to answer that question, we used the Transfer Effectiveness Ratio, proposed by Stanley Roscoe (1971). The Transfer Effectiveness Ratio compares the amount of flight time saved to the amount of time spent in the simulator as follows:

$$\text{Transfer Effectiveness Ratio} = \frac{Yo - Yx}{X}$$

Where: Yo = Aircraft time, control

Yx = Aircraft time, experimental

X = Simulator time, experimental

We found 22 studies which provided data on the time needed to train pilots in aircraft after having been trained in flight simulators as compared to training only in aircraft. These studies produced the 34 data points shown in Table 6; the median Transfer Effectiveness Ratio is 0.48. These data show that pilots trained in simulators learn faster in the air than those trained only in aircraft. The amount of time saved

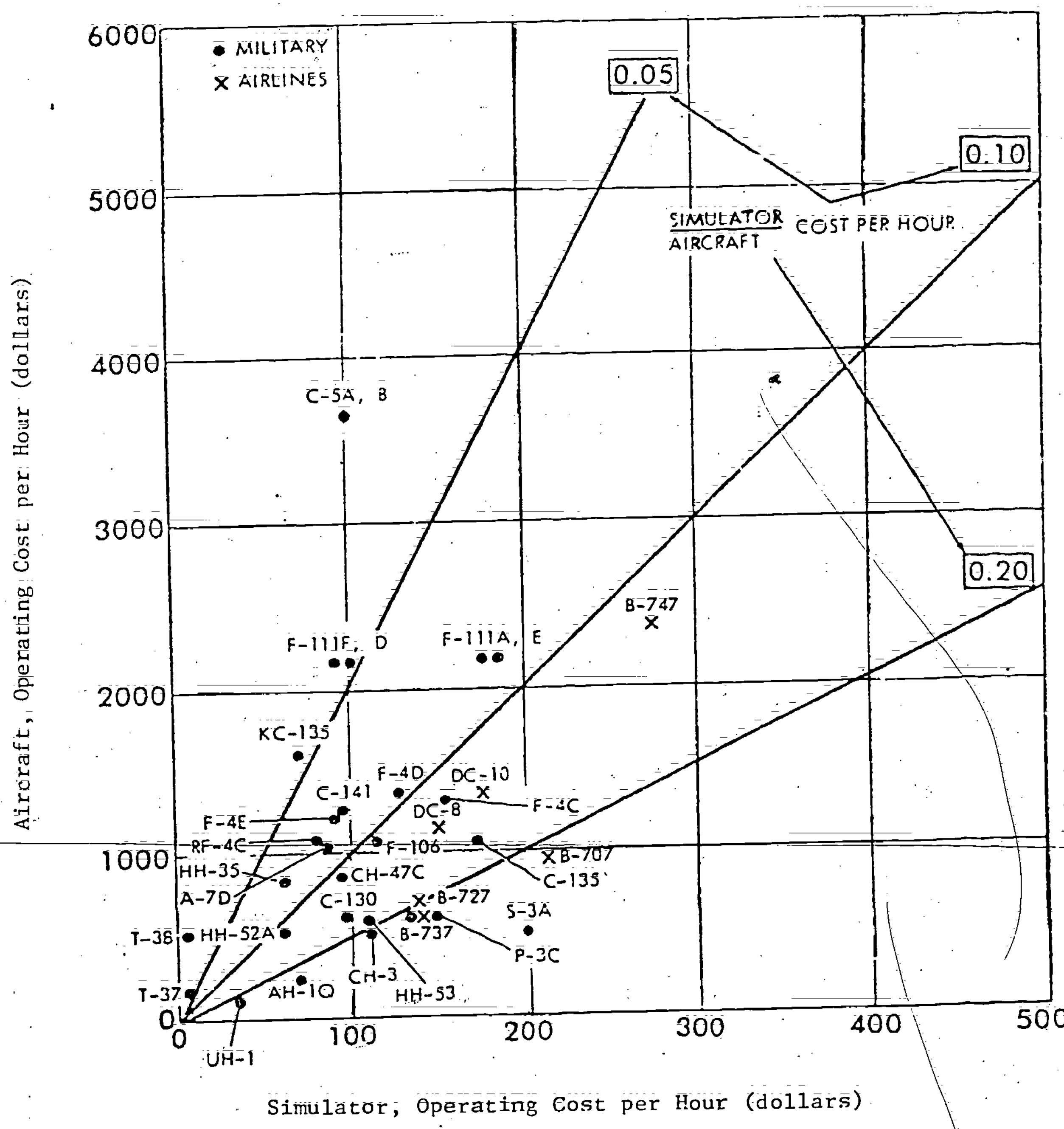
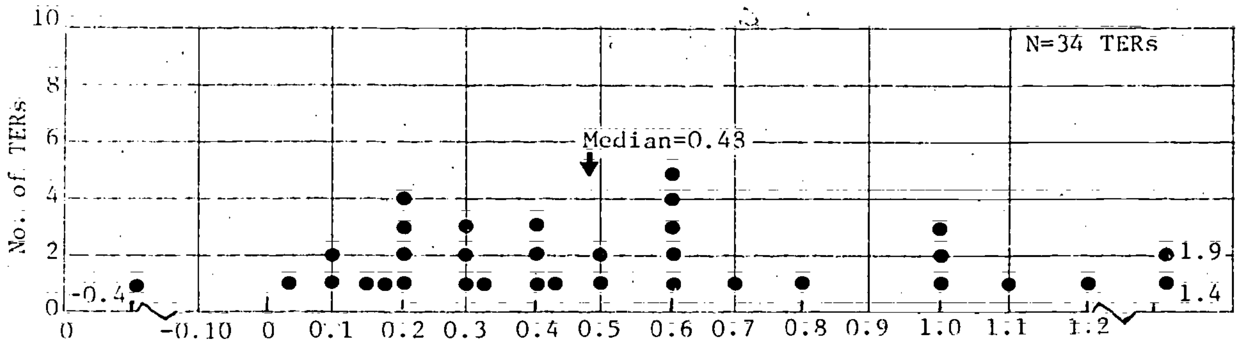


Figure 1. Variable operating costs per hour for 33 simulators and aircraft, FY 1975 and FY 1976.

in the air is about half the time spent in the simulator. There is, however, a very wide range in the Transfer Effectiveness Ratios that have been reported: from -0.4 to 1.9.

Table 6

Transfer Effectiveness Ratios
22 Studies (1967-1977)



According to a recent study by Holman (1979), the Transfer Effectiveness Ratios for 24 different maneuvers in the CH-47 flight simulator varied from .00 to 2.8 (see Table 7).

In general, we can say the following: simulators can be operated at about 12 percent of the cost of operating aircraft; they save about 50 percent of aircraft time. Therefore, flight simulators are cost-effective for training pilots. They remain cost-effective provided pilots do not take more than 8 times as much time in the simulator as it would take to train on some task ~~only in an aircraft (i.e., percent multiplied by 8 will approximately equal~~ 100 percent). Economic studies show that the cost of procuring a simulator can be amortized in two years (the Navy P-3C and the Coast Guard HH-52A/HH-3F); a commercial airline amortizes its simulators in nine months.

Table 7

TRANSFER EFFECTIVENESS RATIOS FOR 24 MANEUVERS
CH-47 FLIGHT SIMULATOR [Trials to Criterion]

MANEUVER	TER
Four wheel taxi	2.80
Cockpit run up	1.50
SAS off flight	1.33
Deceleration	1.25
Maximum take off	1.25
General air work	1.00
Steep approach	1.00
Two wheel taxi	1.00
Confined area recon	1.00
Hovering flight	.79
Normal take off	.75
Confined area approach	.75
Landing from hover	.69
External load briefing	.67
Take off to hover	.63
Traffic pattern	.61
Shallow approach	.58
Normal approach	.53
Confined area take off	.50
External load take off	.50
External load approach	.50
Pinnacle recon	.50
Pinnacle take off	.33
Pinnacle approach	.00

Source: Holman, 1979

Computer-Based Instruction Studies

Before drawing any lessons for future research from these findings, let us briefly consider computer-based instruction for military training. There are four possible methods of instruction: conventional instruction, individualized instruction, computer-assisted instruction (CAI), and computer-managed instruction (CMI); each has been used somewhere in the Department of Defense.

There have been about 30 studies of CAI and CMI in military training since 1968. The courses taught in these studies are shown in Table 8. Each study provides data on student performance with conventional instruction and either CAI or CMI; a few studies also provide data on self-paced instruction without computer support.

Table 8
Courses Used In Various Studies of CAI and CMI

Courses	Number of Evaluations CAI	CMI
Basic electronics	15	
Electricity	5	
Machinist	2	
Training materials development	1	
Recipe conversion	2	
Aircraft panel operation	1	
Medical assistant	4	
Vehicle repair	4	
Weather	1	
Tactical coordinator (S-3A)	1	
Fire control technician	4	
Aviation familiarization		2
Aviation mechanical fundamentals		2
Inventory management		1
Materiel facilities		1
Precision measuring equipment		1
Weapons mechanic		1
Total	40	8

Table 9 shows student achievement at school with CAI or CMI, compared to conventional instruction. Compared to conventional instruction, student achievement is the same or slightly better with CAI or CMI. The small differences found sometimes in favor of CAI or CMI are statistically significant but are not thought to have any practical significance.

Students using CAI or CMI save part of the time required to complete the same courses with conventional instruction; the median value is about 30 percent (see Table 10). There is a very wide range in the amounts of time saved: from -31 to 89 percent. The amounts of time saved by CAI and CMI cannot be compared directly because there is no case where the same course was used for CAI and CMI.

Table 9

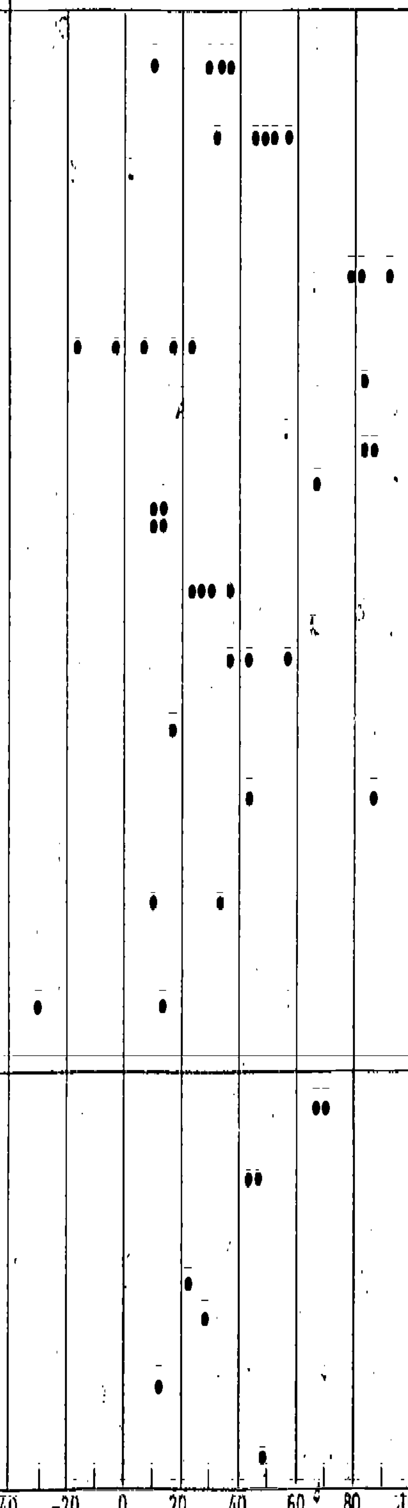
Student Achievement at School for CAI and CMI, Compared to Conventional Instruction, in Military Training

Method of instruction	System	Service	Location	Student Achievement at School (compared to conventional instruction) Inferior	Same	Superior	Type of training	References
CAI	IBM 1500	A	Signal C&S		••••	••	Electronics	IBM (1968), Longo (1969, 1972), Giunti & Longo (1971)
		N	San Diego			•••••	Electricity	Ford & Slough (1970), Hurlock & Lahey (1971, 1972), Ford, Slough et al. (1972)
	PLATO IV	A	Aberdeen		•••		Machinist	U.S. Army Ordnance Center and School (1975)
		N	San Diego		••	••••	Electronics	Stern (1975), Lahey, Crawford et al. (1976), Slough & Coady (unpubl.)
		N	San Diego		••		Recipe conversion	Fredericks & Hoover-Rice (1977)
		N	North Island			•	A/C panel operator	Crawford, Hurlock et al. (1976)
		AF	Sheppard		••	••	Medical assistant	Steinkerchner, Deignan et al. (1977), Deignan & Duncan (1977)
		AF	Chanute		••••		Vehicle repair	Dallman, De Lea et al. (1977)
	CTS-3	AF	Keesler		••	•	Electronics	Harris, Grossberg et al. (1972), Keesler AFB (1972, 1973)
		AF	Keesler		•		Weather	Downs, Johnson et al. (1972)
	TICCIT	N	North Island		•		Tactical co-ord. (S-3A)	Walker (1978)
	IDMOM	N	Dam Neck	•	•		Fire control technician	General Electric Ordnance Systems (1975), Radsken & Grosson (1975)
	PLATO IV	N	Dam Neck		••		Fire control technician	General Electric Ordnance Systems (1975), Radsken & Grosson (1975)
				Total 1	24	15		
CMI	Navy CMI	N	Memphis		••		Aviation familiarization	Carson, Graham et al. (1975)
		N	Memphis		••		Av. mech. fundamentals	Carson, Graham et al. (1975)
	~~AIS~~	~~AF~~	~~Lowry~~		•		~~Inventory mgmt.~~	~~Brieling (1978)~~
		AF	Lowry		•		Materiel facilities	Brieling (1978)
		AF	Lowry		•		Prec. measuring eqpt.	Brieling (1978)
		AF	Lowry		•		Weapons mechanic	Brieling (1978)
				Total 0	8	0		

Table 10

Amount of Student Time Saved in Courses Given by CAI and CMI, Compared to Conventional Instruction, in Military Training

Method of Instruction	System	Service	Location	Student Time Savings (compared to conventional instruction)	Type of training	References
CAI	IBM 1500	A	Signal C&S		Electronics	IBM (1968), Longo (1969, 1972), Giunti & Longo (1971)
		N	San Diego		Electricity	Ford & Slough (1970), Hurlock & Lahey (1971, 1972), Ford, Slough et al. (1972)
	PLATO IV	A	Aberdeen		Machinist	U.S. Army Ordnance Center and School (1975)
		N	San Diego		Electronics	Stern (1975), Lahey, Crawford et al. (1976), Slough & Coady (unpubl.)
		N	San Diego		Recipe conversion	Fredericks & Hoover-Rice (1977)
		N	North Island		A/C panel operator	Crawford, Hurlock et al. (1976)
		AF	Sheppard		Medical assistant	Steinkerchner, Deignan et al. (1977), Deignan & Duncan (1977)
		AF	Chanute		Vehicle repair	Dallman, De Lea et al. (1977)
	CTS-3	AF	Keesler		Electronics	Harris, Grossberg et al. (1972), Keesler AFB (1972, 1973)
	TICCIT	AF	Keesler		Weather	Downs, Johnson et al. (1972)
	IDMOM	N	North Island		Tactical co-ord. (S-3A)	Walker (1978)
		N	Dam Neck		Fire control technician	General Electric Ordnance Systems (1975), Radsken & Grosson (1975)
	PLATO IV	N	Dam Neck		Fire control technician	General Electric Ordnance Systems (1975), Radsken & Grosson (1975)
CMI	Navy CMI	N	Memphis		Aviation familiarization	Carson, Graham et al. (1975)
		N	Memphis		Av. mech. fundamentals	Carson, Graham et al. (1975)
	AIS	AF	Lowry		Inventory mgmt.	Brieling (1978)
		AF	Lowry		Materiel facilities	Brieling (1978)
		AF	Lowry		Prec. measuring eqpt.	Brieling (1978)
		AF	Lowry		Weapons mechanic	Brieling (1978)

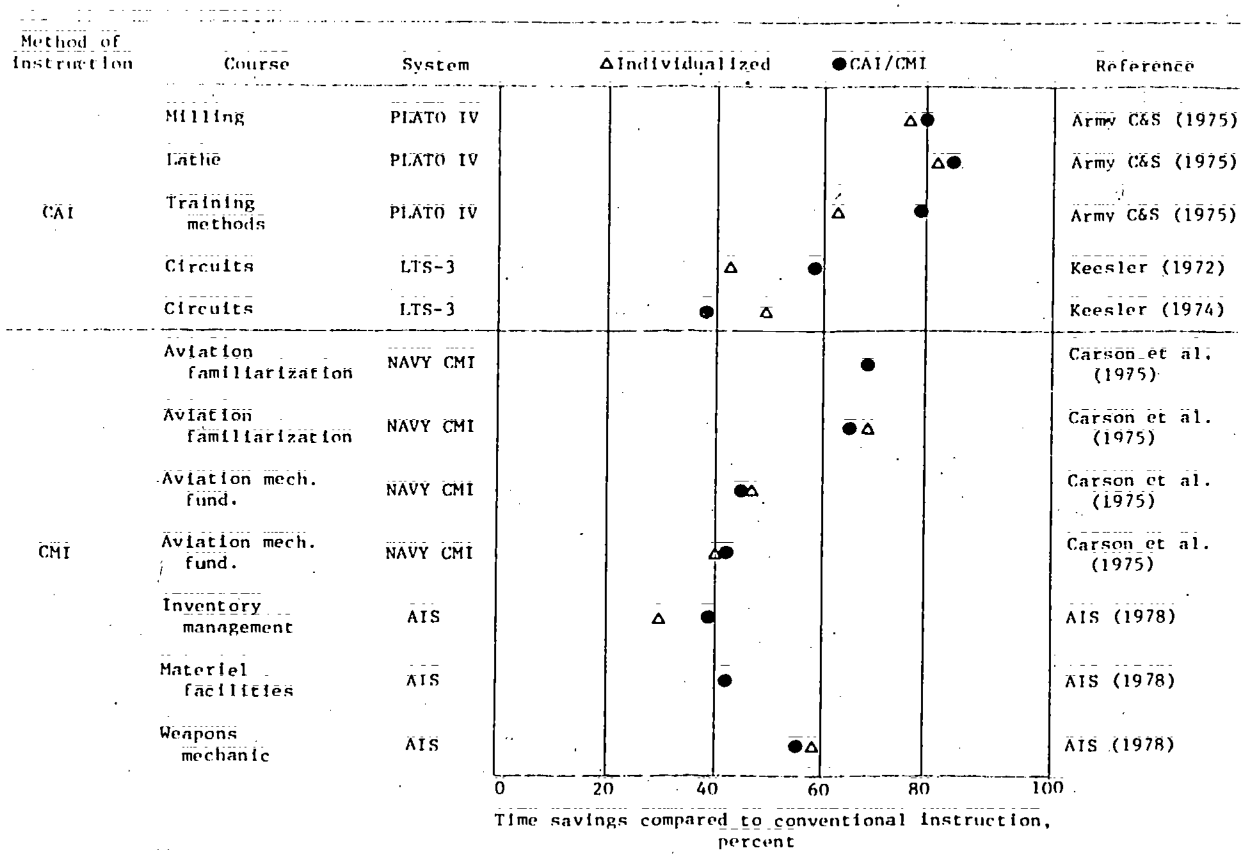


15

There are a few studies where a course was given three ways: by conventional instruction, individualized instruction without computer support, and either CAI or CMI. Individualized instruction without computer-support saves student time as can be seen in Table 11; adding computer-support to these courses does not save much more student time.

Table 11

Amount of Student Time Saved, Compared to Conventional Instruction, by Individualized Instruction and by CAI or CMI on the Same Courses



Four courses were given by computer-managed instruction for about four years at Lowry Air Force Base (using the Advanced Instructional System or AIS). Figure 2 shows that attrition increased in these courses over this period. However, student attrition for academic reasons also increased at the same time in all courses at Lowry AFB. No effort has been made so far to determine how much of the increased attrition is due to the introduction of computer-managed instruction and how much may be attributed to changes in student quality.

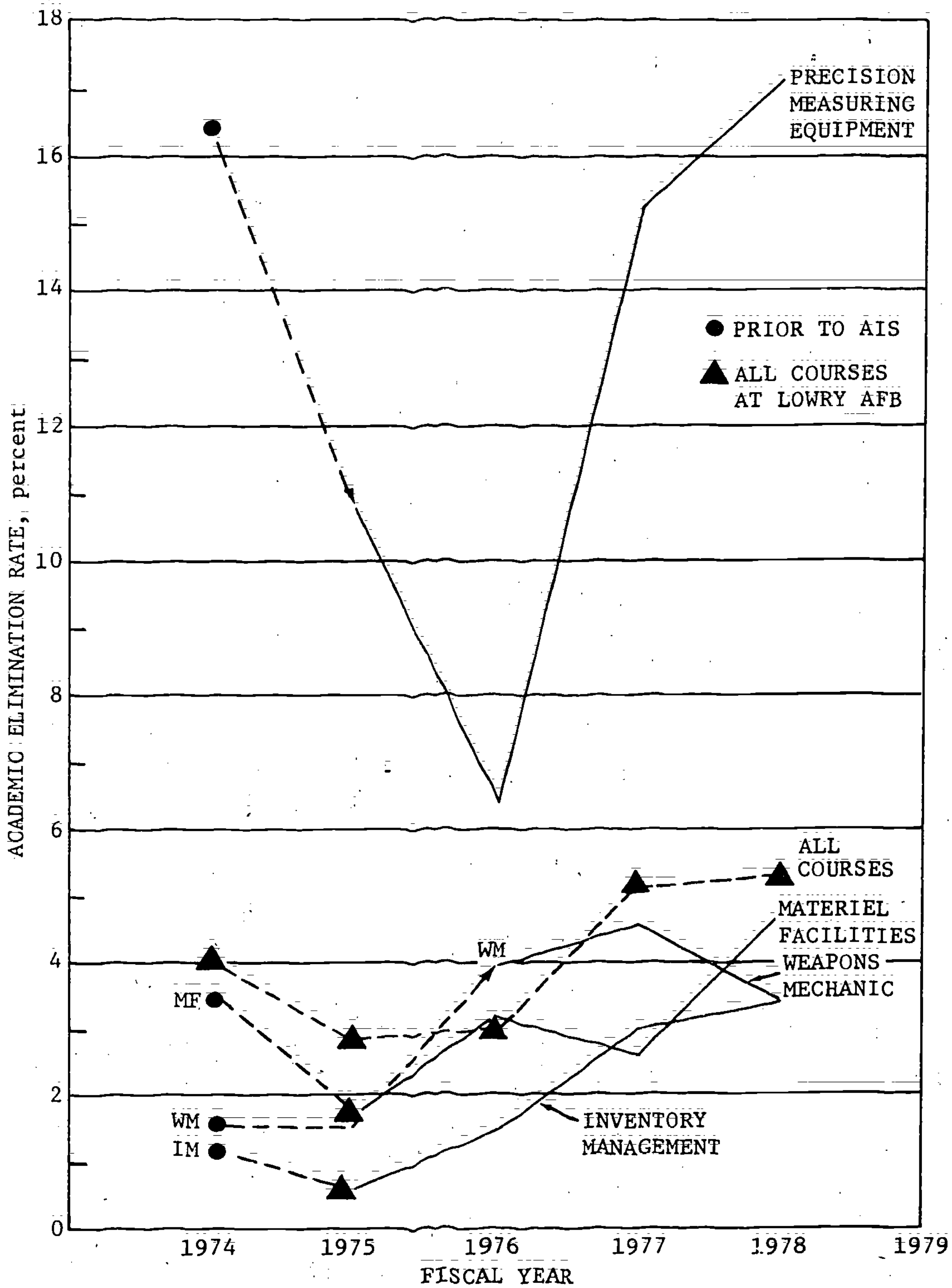


Figure 2. Academic elimination rate in four courses before and after implementation on AIS at Lowry AFB.

These studies also show generally that students are favorable to CAI and CMI; the instructors do not favor CAI or CMI (Table 12).

Table 12

Attitudes of Students and Instructors Comparing CAI or CMI to Conventional Instruction in Military Training

Attitude to CAI/CMI	Students		Instructors	
	CAI	CMI	CAI	CMI
Favorable	29	8	1	-
No difference	1	-	-	-
Unfavorable	1	-	4	4[a]
No report	1	-	27	4
TOTAL	32	8	32	8

Note. All data are number of reports.

[a]Favorable to CMI at first, changing to unfavorable by end of study

The costs of instruction include cost for the procurement of hardware, software and courseware; and for instructors, students, materials, and management. We found only limited amounts of data on the costs of some of the resources needed for instruction (see table 13).

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Table 13

Number of Sources of Data on Costs of Instruction

Resource (type or function)	Method of Instruction: Conventional Instruction	Individualized Instruction	Computer-based instruction: PLATO IV	Navy CMI	Other[a]
Program development					
Program design					
Instructional materials:[b] Conventional instruction					
Individualized instruction		4			
Programming		1			
First unit production[c]		2			
Computer-based instruction			4	1	3
Programming			2	2	2
Coding			2	2	2
Program delivery					
Instruction: Instructors			1	2	
Instructional support personnel[d]				1	
Equipment and services:[e] Laboratory (incl. simulators)	h	h		h	
Media devices	h	3		h	
Computer systems			7	2	8
Communications			5		2
Materials (incl. consumables)[f]					
Facilities[g]		1	2		
Program management and administration					
Student personnel: Pay and allowances			1	2	
Others (PCS, TDY, etc.)[i]				1	

NOTE: Shaded cells are not applicable. Blank cells indicate that relevant cost data are not available.

[a]Includes TICCIT, IBM 1500, LTS-3, GETS, and an experimental shipboard system.

[b]Includes revision.

[c]Master copy.

[d]All direct personnel not included in other categories.

[e]Includes all hardware related costs: initial (including installation and checkout), modification, and replacement; operation and maintenance; lease and user fees; computer system software; etc.

[f]Includes copies of instructional materials (books, courseware copies, etc.)

[g]Structures, fixtures, and furnishings.

[h]Laboratory equipment and media devices are applicable to all methods of instruction (except where simulated in CAI systems), and there is no reason why costs of their use would differ with method of instruction.

[i]Permanent change of station, temporary duty.

As can be seen in Table 14, hardware costs alone for some current systems can vary about $35,000 for a single, stand-alone CAI terminal to over $10 M for a system with 1000 terminals. On a per-student hour basis, the latter would be less expensive than the $35,000 stand-alone terminal provided, of course, that there were enough students to keep all 1000 terminals busy 2000 hours per week for five years. Using the same basis of comparison, CMI systems are much less expensive than CAI systems.

Table 14

Costs of Computer Systems Hardware

Method of instruction	Computer system	Central processor cost (thousands)	Terminal unit cost (thousands)	System hardware cost (thousands)	System hardware cost per terminal (thousands)	System hardware cost per student-hour[a]
CAI	IBM 1500					
	32 terminals[b]	--	--	$ 800	$25	$2.49
	PLATO IV					
	1,000 terminals[c]	$5,000	$ 5.7	10,700	11	1.48[d]
	TICCIT					
	32 terminals[e]	760	2.9	850	27	2.66
	64 terminals	870	2.8	1,050	16	1.64
	128 terminals	970	2.8	1,330	10	1.04
	GETS					
	1 terminal	--	--	34	34	3.40
CMI	Navy CMI					
	6,000 students[f]	2,300	14.3	4,020	34	0.07
	16,000 students[g]	2,300	14.3	6,880	22	0.04

[a] 2,000 hours per terminal per year for 5 years.

[b] Includes maintenance. Based on lease rates and amortizing equipment over a 5-year period, 1967, 1972, 1977.

[c] Control Data Corporation quotation, from private communication dated 14 August 1978.

[d] Based on 725 active terminal constraint.

[e] Hazeltine quotatio , from private communication, 1978.

[f] 120 terminals at 50 students per terminal, 1977.

[g] 320 terminals at 50 students per terminal, 1977.

Discussion

Taken together, these two studies clearly show that research related to flight simulators and to computer-based instruction produced results with significant benefits to military training. Most of the support for research and development in these two areas came from the Department of Defense, although other government agencies were also involved, e.g., NASA on flight simulation; the National Science Foundation and the National Institute of Education on computer-based instruction.

These studies also show that it is possible to evaluate the utility of research; I assume that expenditures for research in some areas have produced little or no useful results. Each of you may have your own ideas of areas of research that should be on such a list.

To avoid a risk of being misunderstood, I'd like to emphasize that I am talking about evaluating applied research and not basic research. Support of studies in the basic research area is determined, presumably, on the basis of such criteria as the relevance of the work to the mission of the Department of Defense (i.e., the criterion specified by the Mansfield Act), the competence of the research team to perform the proposed work, how long it would take to complete the work and whether the required funds are available. It is the responsibility of the basic research groups in the Department of Defense, such as the Air Force Office of Scientific Research and the Office of Naval Research, to identify basic research areas that are particularly relevant to the DoD and to identify those research results which should be developed and used. That is not, *per se*, the direct obligation of the people who do the research.

Now, let's turn to some lessons for future research that may be drawn from the two studies on flight training and computer-based instruction. I wish to use a short and highly relevant list rather than a long and inspiring one to which no one will pay any further attention.

Transfer of Training

What are the factors that influence the amount of transfer of training from the flight simulator to the airplane. I speculate that, among other factors, the amount of transfer has to do with the nature of the task being trained, the level of experience of the pilot, the performance characteristics of the flight simulator and how performance is measured in the simulator and in the aircraft.

Visual Displays

What perceptual characteristics are needed in visual displays of the external world in flight simulators? A visual display, whether generated by a computer or a model-board, it the most expensive component of a modern flight simulator; it may cost from $0.5 M to $6.0 M and account for one-third or more of the cost of a flight simulator. The obvious questions about such visual displays are how much and what types of texture and detail are needed, how to measure the perceptual quality of a display, and what should be its size, resolution, brightness, contrast and color. These are important questions because each of these characteristics can be translated into engineering specifications which, ultimately, affect the cost and complexity of the visual component of a flight simulator.

Student Time Savings

What factors can explain the different amounts of student time savings found in studies of computer-based instruction?

Performance at School and on the Job

What is the relationship between student achievement at school and performance on the job? This question applies to all methods of instruction. I did not mention previously that test scores at school were used as the basis of comparison in all the research that compared computer-based instruction to conventional instruction. My general impression is that military training is intended to prepare personnel to perform some job in the field and only incidentally to pass some test at school. Research on the effectiveness of various methods of instruction has been conducted, so far, on the basis of convenience and not particularly on the basis of relevance to military training.

Student Attrition

Does computer-based instruction really increase student attrition?

Instructor's Attitudes

What steps, if any, could be taken to improve instructors' attitudes to computer-based instruction. This question may invite more applied than basic research. Nevertheless, it is offered as a suggestion to those concerned with research on technological innovation, manpower policy and morale.

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Computer-Based Systems

Beatrice Farr

The term Computer-Based Instruction (CBI) encompasses a broad spectrum of activities--including (but not limited to) computer-assisted instruction (CAI) and computer-managed instruction (CMI). Students learn by direct interaction with computer in CAI, whereas in CMI, students typically learn from books and other sources, but receive guidance and testing via the computer.

Through its integrated themes and in-house and contract programs, the Army Research Institute has supported not only CAI and CMI projects, but also more sophisticated efforts, ranging from artificial intelligence to computerized adaptive testing. Much of the emphasis has been in on-line interactive systems that permit person/computer communication in relatively unconstrained natural language. Army students have characteristically related well to this form of instruction. Current time-sharing computers are not only dependable and endlessly patient, but they have the added advantage of being available to work at all hours and in all environments. However, the computers' instructional effectiveness is limited by the current state-of-the-art with respect to the learning process. Therefore, much of ARI's research has included attempts to answer the questions of why we learn, how we learn and how knowledge is integrated into coherent wholes. It is not inaccurate to say that our computer-based instruction research has dealt as much with exploring the learning process as with controlling it.

Although CBI has not turned out to be the panacea that early devotees predicted, the problem does not lie with computers, whose potential is just beginning to be fully realized. Several trends of the 60's and 70's have converged to change the outlook for the future: 1) there is now a significant body of knowledge garnered from a variety of provocative experiments and conducted in both the private and military sectors, and 2) the amazing progress in computer technology, along with the steady downward spiral of hardware costs has made computerized education look more attractive. ARI is exploring the possibility of combining computers with other spatial data management systems, to provide enhanced interactive capabilities for military education, training and testing. The three abstracts which follow represent a sampling of the computer-based instruction efforts currently being supported.

USES OF COMPUTER-ASSISTED INSTRUCTION IN DEVELOPING AND MAINTAINING PSYCHOMOTOR SKILLS

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BACKGROUND

The University of South Dakota research program in psychomotor training is based on three theoretical sources. A primary concept has been the segregation of psychomotor learning into three discrete categories comprising a) paired-event learning; b) integrated sequences of activity (ISAs) and motor schemas and c) translation functions. These categories have evolved from distinctions first made by Welford (1976) and Stelmach (1976; 1978), which can be elaborated into a systematic organization of parallel, simultaneously available psychomotor storage and execution mechanisms.

Each of these three major storage and execution systems has a unique pattern of acquisition over time, of decay over time, and of degradation under stress. It is only by monitoring these acquisition, decay and degradation patterns that the relative contribution of each system to a given skilled performance can be determined. It happens that the mechanism mediating the formation of motor schemas and integrated sequences of activity is the one most amenable to computer mediated interactions with the skill-acquisition processes required for heavy machinery operation.

A second theoretical source of our computer-mediation procedures is D. H. Holding's description of the various possible formats in which knowledge of results may be presented to a student (Holding, 1965). Holding observed that the nature of such knowledge was an integral feature of any psychomotor training system. Knowledge of results may be either intrinsic or extrinsic-the extrinsic knowledge being artificial, supplementary, and arbitrarily scalable. Extrinsic knowledge of results may be concurrent or terminal, discrete or cumulative, and immediate or delayed. Each format has advantages and disadvantages that must be evaluated on a case-by-case basis.

The final source of our training interactions arises from the field of biofeedback training, in which artificial displays of physiological events are used to develop volitional control of the underlying physiological mechanisms. The biofeedback literature (Aldine Annuals, 197?-1977) is a rich source of examples of studies in which the problems of formatting and presenting supplemental displays during a training process are dealt with, particularly the problem of weaning the experimental subjects from reliance on supplemental or extrinsic displays, and establishing a performance based entirely on intrinsic cues.

PRIOR RESEARCH PROGRAM

Our experimental program to date has used a truck-transmission gear-shifting task as a "test bed" task which could be readily learned and was readily scalable as to performance quality in several dimensions. This task has been taught to several dozen groups of subjects using different formats of extrinsic supplemental displays and different rates of display updates (Phillips & Berkhout, 1978). We have found that continuously available analytic displays do enhance task acquisition, but that these displays in effect convert a portion of the learning task into a tracking task. The process of withdrawing the display then produces a substantial performance deficit. We also found that terminal displays, both numerical and analytic, and both discrete and cumulative, were useful tools in initial training. They were also efficient aids in re-establishing performance after a period of several weeks of disuse. As in most biofeedback environments, the displays were presented without detailed instructions and did not incorporate discrete error messages.

The problem of withdrawing the supplementary knowledge of results is a major one. Degraded, truncated or faded displays have proven to be very poor techniques for weaning students. Alternating display and no-display conditions is more promising. While analytic displays may be better training tools, numerical displays are more readily withdrawn. After long periods of disuse, numerical scores are more efficient than analytic displays in re-establishing original levels of performance.

The value of computer technology in preparing and presenting these displays is pervasive and ubiquitous. Even small amounts of calculating and formatting capability have proven to be of value, although the more power available, the more sophisticated the displays can be. Computer capability is also of value in storing historical data providing ready comparisons between current performance, historical performance, and reference group data for individuals or large trainee reference groups. While extremely high fidelity task simulation and rapid response time may be necessary for multi-crew interactive training, virtually any small amount of computer capability can be used to advantage during the stages of individual skill acquisition in a part-task simulation.

CURRENT RESEARCH PROGRAM

Current studies call for training all subjects to a certain criterion level of skill, with the time required to reach such levels being the dependent variable. This seems to be more comparable to present military training practice than our prior procedure of exposing all students to equal lengths of training. As one aspect of our current program, we will continue to explore various formats of displays and withdrawal procedures. Particular effort will be devoted to developing concurrent displays which are compatible with ongoing tracking acoustic displays for use during this early part of training. Current work is similar to our prior studies in general design, but will carry the students to a higher level of performance, and explore additional display formats.

Our current program also includes a study of computer-managed instruction. The interaction of man and machine in a monitored simulator generates enormous amounts of data about the students' performances, most of which is lost in present types of training since it cannot be presented to the student in any meaningful way during the process of skill acquisition. While computer-assisted instruction - in which a small portion of this data is available to the student - enhances the learning process and is more cost-effective than live one-on-one instruction, it is possible that greater benefits could be provided by displaying the available information to an instructor. Under a computer-managed training system, the instructor can monitor several students simultaneously, and can examine much more information about the students performance than they could digest themselves. The problems of formatting and updating displays are similar to those encountered in the computer-assisted environment. We intend to run training sessions in which naive subjects are drawn from the student pool, and given a limited amount of instruction in teaching the task at hand, rather than performing it themselves. These novice instructors will have a large amount of information available to them and various ways of organizing and presenting it will have to be developed.

Proper CAI strategies may also facilitate the integration of part task into whole task performance. We are exploring the use of the computer as a timing and cueing device, to be used in bringing the pacing and sequencing of learned subtasks under some form of control. In this approach it is convenient to separate the three mechanisms of psychomotor learning defined above, and break them individually out of the overall performance environment. Computer mediated cueing and pacing instructions can serve to enhance paired-event responses and limited schemas which may be embedded in a more elaborate learned sequence of motor outputs.

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THE DESIGN OF USER-COMPUTER GRAPHIC CONVERSATIONS

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The subject of our research is interaction techniques for use with computer graphics systems. Interaction techniques are employed by graphics system users to convey commands and other information needed to carry out the commands. There are a multitude of interaction techniques. Each has some purpose, such as to specify a command, designate a position, or select a displayed objective, and is implemented with some device, such as a tablet, joystick, keyboard, light pen, track ball, or potentiometer. Typical techniques are command selection from a menu using a light pen, specifying a position using a tablet or joystick along with cursor feedback on the screen, typing a numeric value on a keyboard, or designating a displayed object with a light pen.

Interaction techniques and devices are an important part of the user-computer interface. We all recognize, from our own experiences with interactive computing (not necessarily with interactive graphics), the costs of poorly-designed interfaces. Coming in many forms, the costs can include less than peak user productivity, user frustration, increased training costs, the need to redesign and reimplement the user interface, etc. Specific experiments confirm that the costs are real. How can we avoid these costs? Where can we turn for guidance? There are three basic sources of information: experience-based guidelines, experiments with interaction techniques, and traditional human-factors texts.

Over the past ten years much experience-based lore has developed concerning what makes interactive graphics systems easy (or hard) to use, and concerning the pros and cons of various interaction devices and techniques. Much of this lore has not found its way into the literature. Furthermore, that portion of the lore which is found in the literature is typically scattered amidst application descriptions. Only a few writers have attempted to summarize their design philosophy or their accumulated knowledge and experience. These papers represent one source of guidance.

A modest collection of experiments comparing different interaction techniques has been undertaken, starting in the late 1960's. Some of the experiments have been performed by computer scientists, others by human factors specialists, and still others have been done collaboratively by multi-disciplinary teams. The results of these experiments are often useful, although generalizing beyond the specific circumstances of the experiment can be difficult.

The final source of guidance is the "traditional" human factors texts, which typically concentrate on human capabilities and capacities, auditory and visual information presentation, human control of systems (not generally of computer systems), and arrangement of work spaces. A few more contemporary texts give major consideration to computer issues.

The difficulty with these sources of guidance is that they are sometimes hard to locate, may be the jargon of experimental psychology, and hardly ever use consistent terminology. Consequently, the designer of an interactive system must to a large degree rely primarily on personal experiences, and on those of colleagues.

The intent of this research is to integrate, within a unified and logical structure, a significant and useful body of the experiential and experimental conclusions drawn from these sources.

There appear to be six basic interactive tasks in an interactive graphics dialogue. They are:

Select	from a set of (displayed) options
Position	a cursor or displayed entity
Orient	a cursor or displayed entity
Path	create a sequence of positions or orientations
Quantify	with a scalar value
Text Input	a character string

Each task can be implemented with any number of different techniques, using many different devices. The techniques can be compared on the basis of their speed of use, error rate, learning time, and fatigue factor (which is reflected in speed and errors).

Each of these comparison factors has roots in the cognitive, motor, and perceptual components of a technique. To be able to precisely identify these components, we have developed technique diagrams, a way to represent many of the details of a technique. The diagrams also have proven useful in our study of experiments dealing with interaction techniques.

The results of this work will be:

A designer's handbook, describing the techniques and making recommendations as to their effectiveness in various situations.

Recommendations for experimental investigations of certain techniques.

Technique diagrams for the techniques and experiments.

A summary and critique of relevant experiments.

COMPUTERIZED ADAPTIVE ACHIEVEMENT AND ABILITY TESTING

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Adaptive Ability Testing

Placement of recruits for effective utilization of each person's capabilities has been an important problem to the military services, and considerable research has been directed toward accurately measuring each recruit's abilities. Ability test batteries have been developed for this purpose, but until recently have been limited in their usefulness because of the restrictions imposed by their paper-and-pencil mode of administration. However, the use of interactive computers to administer ability tests has brought with it the promise of improvements in the measurement of both ability and achievement by utilizing the capability of interactive computers to dynamically adapt (or tailor) the test to the individual during the process of testing. Early studies on computerized adaptive testing (CAT) (Weiss, 1973, 1975, 1977, 1978) supported the predictions of more precise measurements and a more efficient measurement process.

Given the availability of interactive computers for the administration of ability tests, there are many ways of adapting tests to the individual. Thus, an important focus of this research is to evaluate the relative utility of a variety of adaptive testing strategies. Earlier studies (Weiss, 1975) were primarily concerned with the comparison of these strategies under perfect conditions by computer simulation, or in non-military populations. A recently completed study in a military recruit population, however, showed consistently higher reliabilities and validities for an adaptive test in comparison to a conventional test of the type currently used in the ASVAB. The data showed, for example, that an 11-item adaptive test achieved the same validity as a 29-item conventional test.

A second study was concerned with the performance of adaptive testing strategies under realistic conditions in which the test item parameters (e.g., difficulty, discrimination) had varying degrees of error in them. The data showed some differences in correlations of estimated and true ability levels for adaptive testing strategies for very short (10-item) tests, and virtually no differences for 30 item tests. In addition, even when the adaptive tests were administered with error-laden item parameters, their validities were consistently higher than those of conventional tests with error-free item parameters. Taken together, these two studies support the higher validities of adaptive over conventional tests under realistic testing conditions.

Adaptive Achievement Testing

The second focus of the research program is the adaptive measurement of individual achievement within an instructional setting. Two applications of adaptive testing technology to the measurement of achievement are currently being investigated: 1) the use of an Adaptive Mastery Testing technique to make educational decisions, and 2) the development of a procedure for Self-Referenced Testing to measure individual growth in achievement.

Adaptive Mastery Testing (AMT). The AMT procedure (Kingsbury & Weiss, 1979) is designed to allow decisions to be made concerning an individual's current achievement level, relative to some fixed criterion level(s) for desired performance (i.e., mastery levels or grading standards). By expressing the usual percentage correct mastery levels in terms of the achievement continuum used in item characteristic curve (ICC) theory, CAT procedures may be used to quickly and accurately determine whether an individual passes or fails to pass the criterion levels.

The efficiency of the AMT procedure has been investigated in both real data and monte carlo simulations which have shown the AMT procedure to be effective in reducing test length by 30.4 to 61.3 percent using a real item pool, while obtaining the same decision as a conventional test for 89.4 to 98.5 percent of the examinee population. Using an artificially constructed item pool and simulated examinees, the AMT procedure reduced the conventional test length by 13 to 53 percent, while making the correct decision more often than the conventional test.

Self-Referenced Testing (SRT). SRT refers to the measurement of individual growth in achievement during a course of instruction, by measuring an individual at several different times during instruction to determine whether or not the course has had an effect on the individual's achievement level. In mastery SRT each student is tested against a personal standard of performance, rather than a preset criterion level, which is constant for all individuals. SRT is designed as both a diagnostic and an evaluation tool. By examining an individual's SRT achievement profile at various times during the course of instruction it might be possible to identify individuals with certain types of learning disorders or individuals who were incorrectly placed in the instructional sequence. Or, by identifying similarities across many individuals' profiles, it might be possible to detect points at which the instructional procedure needs to b improved.

The implementation of SRT requires both ICC theories and procedures and CAT procedures. The result should be measurements of individual growth which have adequate precision without prohibitive test length.

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Information Processing

Glenda Y. Nogami

Information processing is an integral part of effective military functioning. A soldier must be able to accurately identify and classify relevant new information, process and use that information, and store it for future use. The papers in the session represent the broad range of information processing problems under investigation.

Biederman's research focuses on identification and interpretation of information. He investigates the 5 classes of relations (interposition, support, probability, position and familiar size) which aid in distinguishing between a real-world scene and a display of unrelated objects.

Can people be trained to use only relevant/diagnostic information in making decisions? Shanteau's results indicate that decision makers can be taught to ignore non-diagnostic information through "active training."

Galanter's presentation is on the processing and the use of information under less than optimal conditions--performance at night. Galanter differentiates between performance in the dark (one dimension of "night") and performance during a specific time frame during the quotidian cycle.

Kerst and Howard are concerned about the processes by which people are able to store cartographic information and recall that information for later use. Their investigations reveal that storage, accession, and manipulation of visual and spatial relationships can be understood with psychophysical principles.

HUMAN INFORMATION PROCESSING OF REAL-WORLD SCENES

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Of fundamental importance to the functioning of many Army personnel is the interpretation of information from real-world scenes. While most central to such activities as target detection and acquisition, image interpretation, visual flight reconnaissance and vehicle control, the efficient interpretation of scenes comprises a vital criterion for the evaluation of a wide range of military applications from equipment design to camouflage. The focus of this research is on the perceptual recognition of real-world scenes, particularly on how people are able to comprehend a novel scene in only a fraction of a second.

What is it that distinguishes a real-world scene from a display of unrelated objects? Surprisingly, only five classes of relations between an object and its setting may be sufficient for characterizing much of this distinction (Biederman, 1980). A major experimental strategy which we have been following to study scene perception was to violate one or some of these relations so that incongruities were produced between an object and its setting. The violated relations were of 1) Interposition (or occlusion), so that the background appeared to be inappropriately passing through an object, 2) Support, so that the object appeared to be floating in air, 3) Probability, so that the object was unlikely to be in that particular scene (e.g., a fire hydrant in a kitchen), 4) Position, so the object, which was probable in the scene, was in an inappropriate position (e.g., a fire hydrant on top of a mailbox in a street scene), and 5) Familiar Size, so that the object appeared to be too large or too small.

Relational Violations and Scene Perception

The Effects of Relational Violations on Object Detection

In Object Detection experiments, the effects of these violations on the speed and accuracy of object detection were measured. In these experiments, prior to each trial the subject read the label of a target object, e.g., "fire hydrant." A central fixation point was then presented for 500 msec., immediately followed by a 150 msec. flash of a slide of the scene. The scene was, in turn, immediately followed (in the post cueing experiments) by a cue (a dot) embedded in a mask of random appearing lines. The position at which an object had been centered in the scene. On half the trials, the cue pointed to the object that corresponded to the target name and the subject was supposed to respond by pressing a "yes" key. Cued objects could either be in a normal position or undergoing one, two, or three violations.

Targets undergoing violations were less accurately and more slowly detected than when they were in a normal context. In general, the more relations an object violated, the more difficult its detection. Violations of the pervasive physical constraints of Interposition and Support did not interfere with detection more than the violations of those relations dependent upon access to the referential meaning of the object, viz., Probability, Position, and Size. Also documenting this remarkably fast access to semantic relations were the results of an experiment in which the target position was pre-cued; i.e., where the cue preceded the scene. That is, not only did subjects know what target to look for, they also knew exactly where to look. Even under these conditions, violations retarded the detectability of targets. In fact, an effect roughly analogous to the Reicher (1969) effect was obtained, in that objects in a normal position were identified more accurately than when presented by themselves. (The Reicher effect is that the identification of a letter when embedded in an English word is more accurate than when presented by itself.)

The Detection of the Violations

In Violation Detection experiments subjects attempt to detect not the target object, but the presence of the violations themselves. These tasks are roughly analogous to grammaticality (or acceptability) judgments of sentences. The sequence of events on a trial is comparable to the pre-cueing Object Detection experiment. The subject was first provided with the name of a target object, then a fixation point was presented which designated the position where the target always would appear. The scene was then flashed (followed by a mask).

In one (typical) experiment, the scenes were presented for 150 msec. and all of the violations save one were detected at a very high (80-90%) level of accuracy. Violations of Interposition, however, were detected on only 60 percent of the trials in which they occurred. Chance was 50 percent. Multiple violations were detected at accuracy levels greater than 90 percent.

To explore further the detectability of the various violations, another experiment was run in which the scenes were presented at very brief durations, from 25 to 75 msec. At 25 msec., performance for detecting both the presence of the violations as well as the accurate judgment of a normal relation was at chance. As the exposure duration was increased from 25 to 75 msec., subjects were able to detect all the violations with increasing accuracy save one. The detection of Interposition became less and less accurate as exposure durations increased until it was significantly below chance at 75 msec. exposure duration. Why did this occur? Although violations of Interposition would affect the course of a figure-ground segregation system, it is our hypothesis that object identification does not require a preliminary figure-ground segregation. An object's contours can elicit recognition directly. With increasing exposure duration, the processing of these contours becomes more and more accurate yielding an increasingly accurate recognition of an object. The detection of a violation of Interposition, instead of being quickly signaled by an early figure-ground segregation system, requires the detection of fine line segments which do not yield a recognizable object. The realization that an aggregate of line segments is not yielding an identifiable object may be an achievement that is relatively slow compared to the recognition that a well-defined object is in an otherwise (with the exception of the Interposition violation) normal relation to its context. Put another way violations of Interposition might produce wrinkles in an otherwise well-formed object in a normal relation to its setting. These wrinkles retard neither the identification of the object nor its relations to its setting.

The results of both the Object and Violation Detection experiments thus document a remarkably fast access to the semantic relations among the objects comprising a scene: fast enough for violations of these relations to affect the detectability of individual objects (in the Object Detection experiment) and to be available even before the relations reflecting pervasive physical constraints (in the Violation Detection experiments).

One last experiment provided further evidence for the relative speed in the availability of the semantic relations. In a Violation Detection experiment where subjects were instructed to detect only the presence of a single kind of violation, e.g., Support-violations of semantic relations (e.g., Probability) interfered with these judgments. That is, the semantic relations can be accessed so quickly as to affect not only the detectability of individual objects, but also the detectability of the physical violations. The last result underscores the important point that not only are the various relations accessed simultaneously, but that this access is obligatory. That is, we cannot help but see a given object as floating in air or improbable or out of position or looking too large or too small.

Routes to the Top: How Do We Access Semantic Relations?

How are semantic relations accessed so quickly? Two routes to the top--to schematic (or semantic) information--are being investigated. One route is through an initial identification of one (or more) of the highly discriminable objects in a scene. This processing of the first object(s) would be independent of the processing of the other objects. The implication of the route is that once an object is identified in the scene, we may quickly know the kind of company it keeps. That is, we have access to the probability relations. This information would then be used to influence the course of object identification in another part of the scene. So, for example, if in looking at a scene we recognize or detect a stove, that will facilitate the perception of an object in another part of the scene, say a coffeepot. There is no doubt that we could use this information in a task that was relatively undemanding with respect to time. Given enough time in looking at a display of apparently unrelated objects (unrelated in the sense of having a consistent layout in a real-world setting), there is no doubt that we could categorize these objects as likely to occur from one kind of scene rather than another. Thus, if we see a stove, a refrigerator, a cup, a sink, and a pot, we could likely infer that these are all objects that would occur in a kitchen. But would the identification of one of these objects affect the speed of identifying another of these objects?

The experimental displays to test this route involve from one to six pictures of objects arranged around an imaginary clockface. In a modification of the Egeth, Jonides and Wall (1972) task, subjects attempt to detect whether a given target object is present in the display. The main variable is the likelihood of the target object occuring amongst the objects in the display. In the High Probability condition, for example, the target could be "lamp" and the display could contain drawings of an armchair, an end table, a bookcase, a magazine, a lamp, and/or a coffeetable. On a trial when the target was not in the display, a stereo might be shown in the place of the lamp. All of these objects could have come from a living room. In a Low Probability condition, the display could consist of a barn, a pig, a silo, a tractor, a cow, and/or a chicken. Egeth, et al. (1972) reported that a digit would appear to "pop out" from a display of letters. Would a lamp "pop out" from a display of barnyard creatures and objects? If so, or even if the results went in the opposite direction in which the lamp was more difficult to detect amongst barnyard objects, this would document a rapid access to the probability relations even in the absence of a scene-like arrangement of the objects.

A second, perhaps more interesting route to the semantic relations might be via features that are not those of individual objects but "emerge" as objects are brought into relation to each other to form a scene. The form of such features is not known but their existence might be testable from an experiment in which the features of the objects comprising a scene were so degraded that the objects were unrecognizable when presented individually. The critical question is whether scenes can be constructed in which these objects become identifiable when placed together to form a scene. This result would suggest that individual features from different parts of the visual field might combine to elicit the semantic relations for a group of objects which, in turn, can exert a top-down effect to influence identification.

Background Gradients, Expectancy and Familiarity: Some Routes Not Taken

Our experiments have provided evidence against three possible routes by which scenes can be rapidly and accurately perceived. One of these routes was through the existence of an arrangement of the objects in depth. In an experiment that compared the effects of presenting six unrelated objects against a depth-like background (i.e., a path, railroad tracks, or a corridor), the depth-like arrangement did not facilitate identification compared to a blank background or a non-depth control grid. The critical point about this experiment was that the objects could not be related semantically. This suggests that spatial relations will only have a beneficial effect on object identification to the degree to which they aid in the achievement (or are consequences) of some unitary semantic representation of the scene. That is, if the collection is a scene--say, a kitchen--then the perspective information could aid in the achievement of a schema for the kitchen which, in turn, might facilitate the recognition of the objects.

There is typically a degree of predictability (or expectancy) from one glance to the next in our visual world. We might expect to see a living room when we entered a house for the first time--not a Burger King. We experimentally tested whether such predictability could facilitate processing by priming a subject, prior to the viewing of the scene, with a descriptor for that scene, for example, "kitchen." Would the perception of a kitchen be faster and more accurate than if such a prime was not provided? The theoretical issue under scrutiny here is whether generic routes to a schema exist which, if activated in advance, could facilitate perception.

With respect to familiarity, it is the case that often--but not always--we have previously experienced the scenes which we encounter in our day-to-day lives. Can our perceptions capitalize on this experience? We posed this question in the context of our experiments by repeating scene backgrounds during the course of the experiment. On half the trials, a verbal prime was provided. The results were simple. Despite the fact that the scenes were processed to a semantic level--as evidenced by an effect of violations of the semantic relations, neither priming nor repetition of the scene backgrounds--that is, neither expectancy nor familiarity--facilitated the perception of a scene.

Conclusions

From a single fixation at a picture of a novel scene, a viewer can often extract sufficient information to comprehend that scene. Neither a sequence of eye movements nor motion in the scene or observer are necessary for this processing. Semantic relations are accessed at least as rapidly as relations reflecting the pervasive physical constraints of Interposition and Support which are not dependent upon referential meaning. The mechanisms for perceiving and interpreting real-world scenes can be triggered so quickly and efficiently that conditions can readily be found in which an expectance for a scene or familiarity with it are neither necessary nor even helpful toward its perception.

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HUMAN PERFORMANCE AT NIGHT AND IN DARKNESS

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Continuous and night operations have been an intrinsic part of military activities since the latter part of the fifteenth century. Our understanding of continuously operating systems have not advanced as rapidly as the requirements for personal participation in such environments. Earlier concerns about human performance at night focused on one particular organismic change induced by those reductions: the dark adaptation of the human retina. The observed behavioral effect is a reduction in the absolute threshold for a visual stimulus during the first thirty minutes of darkness. Other similar lines of psychophysical inquiry have explored the control over human detection and discrimination exerted by the energy contained in the visual stimulus. These data have led to the examination and elucidation by sophisticated experimental paradigms of human factors constraints in the design of visual displays. The data have also led to definitions of illumination standards for a variety of tasks, including vehicle control operations and system monitoring situations.

Technology has largely overtaken these issues in the form of night vision aids and forward-looking infra-red scanning systems. Thoughtful consideration of the effects of visual degradation as a result of low ambient illumination always recognized a component that was "psychological." That is to say, difficulty in perceiving may lead to difficulty in coping with tasks that were not of a primarily visual kind. We believe these difficulties and their effects of performance may be induced by emotional, motivational, and attitudinal shifts that may be brought about by darkness and/or night.

Night and continuous missions often require people to work under conditions of reduced sensory information (darkness) at a time (night) when information processing and decision making capabilities are less than ideal. In order to understand the nature of human performance at night, it is necessary to separate analytically the two aspects of the human operator's task: performance in the dark and performance at night. Night missions, of course, combine both performance aspects, but this empirical co-occurrence should not deflect attention from the fact that these aspects must be distinguished in order to assess their contribution to possible decrements in human night time performance. That is, darkness may induce performance difficulties that get superimposed on problems that are elicited independently by phase shifts in the rest-activity cycle.

Our investigation of these problems has taken two lines: experimental studies to examine the effects of darkness and nighttime, and the development of technologies that will permit us to investigate individual feelings and attitudes concerning continuous and nighttime activities. We attend first to a review of experimental studies which themselves are either laboratory experiments or field experiments. The central purpose of these experiments is to see whether we can demonstrate differences in performance that correspond to changes that accompany motivational or emotional alterations induced by darkness or time-of-day. For example, we have found that when people make judgments about the "loudness" of variations in the intensity of acoustic stimuli, those scales remain invariant when the observers are subjected to variations in induced stress. But let the judgments be changed to "annoyance" instead of loudness, and the slopes increase when stress is induced. We have redone this experiment after changing the ambient illumination in the environment in which the judgments are taking place. Under these conditions we find that although loudness judgments do not change, judgments of annoyance grow more rapidly.

These judgments in the dark do not yet answer questions about the effects of night. Before we turn our attention to field experiments conducted to assess whether performance at night is poorer than performance during the day, we must introduce an observation that comes from the other line of our research--the development of instruments for the conduct of survey-type studies. In that work, when we assess the effects of time-of-day differences on a variety of judgments, we note a consistent difference between judgments concerning events and activities that occur in what we call "evening" and events in the "nighttime." "Evening" refers to that period of darkness between approximately 8 pm and midnight local time. "Nighttime" references the hours between 1am and 5 am.

The development of these social survey time-histograms suggested the importance of the evening-nighttime distinction. Consequently, our field experiments attempted to record observable behavioral differences in skilled performance conducted during the evening and at nighttime. The general hypothesis is that whenever skilled performance requires cognitive functioning that is sensitive to affective or emotional interference, we may expect the performances to show deficits. In many tasks, the human operator is functioning at levels of performance far below those called upon during all-out cognitive and perceptual-motor loading. Therefore, if we are going to observe these effects, it may be necessary to select a task that places a high workload on both cognitive and perceptual-motor processes. We make use of a flight task that requires an aircraft pilot to make a solo approach and landing to an uncontrolled (no radio transmissions) airport under conditions of darkness. These preliminary studies were conducted either in the evening; that is after 9:30 or at night between 2:30 and 4 am. Notice that a pilot flying an airplane "on instruments" is operating in an environment that is insensitive to the time-of-day. We, therefore, chose to conduct a "visual" approach that required the pilot to scan actively outside the cockpit and to control the aircraft by visual reference alone. In order to establish opportunity for any effective components of night or darkness to develop, the approach path required approximately six minutes of flight over the ocean with no artifacts visible.

The quantitative data consist of photo-theodolite measurement of thirty observations per approach. Deviations from the approach path are represented by the bi-variate scatter of the data points. Our initial studies tend to confirm (both objectively and by subjective reports) the hypotheses that nighttime is more affect-laden than evening and that performance is poorer. We are planning further laboratory experiments to confirm these findings, and to examine physiological and psychological variables that may serve as indicators of system differences and variations.

We return now to an overview of the methods we are developing to identify people who may differ in their effectiveness during the quotidian cycle. Such variations among individuals may provide a basis for selecting personnel for performance in tasks and missions that require continuous or nighttime activities. On the other hand, if such individual differences are not detectable, we may find from laboratory or field studies possible training techniques, task displays, or even pharmacological aids that may be useful to improve performance, or attitudinal or motivational tolerance for contineuous and night operations.

The central notion behind this new scaling technology that we have developed is that human desire and aversion and the concommitant affective states that they represent are, in principal, embeddable in a one-dimensional continuum that we (as well as others) call a "utility scale". The cultural representation of such a utility scale takes its most obvious form in "money". As a consequence, we construe the monetary metric as the physical representation of the psychological dimension of "desire" and "aversion". Because of our interest in aversive aspects of various psychic states, the aversion or disutility scale is the one we have developed most fully. It is essentially a scale that estimates the distribution of incremental disutility of a particular event from the same person without having him simply repeat his answers in order to appear consistent and coherent. The technique has him compare the object of our interest (say, "the desirability of working on the night shift") with a multitude of variously aversive life-familiar events. If now, we know the disutility scale values of these life-familiar events, then we can estimate the disutility distribution of the particular situation we are trying to measure by comparing that event with the multitude of life-familiar events.

The central technical problem, therefore, was to scale the life-familiar events that measure the disutility. To do this, we first showed that we can generate a utility function for life-familiar events that conform to disutility associated with monetary losses of varying magnitudes. These differential monetary losses are shown first to have utility values that are a power function of money and, consequently, will regularly or consistently translate disutility to losses in dollars. When other life-familiar events are simultaneously scaled with the monetary losses, we may assume that their disutilities (the life-familiar events) are as reliable as the disutility of the monetary losses. If the dollar losses show an intrinsic regularity, then we assume that the disutility of the life-familiar events have equivalent validity. We are now in a position to construct survey questionnaires for which the utility scales of various activities can be measured. We anticipate highly reliable data that will enable us to distinguish between "larks" and "owls", if such differences exist.

These techniques--laboratory, field, and survey--have demonstrable efficacy in having identified and isolated a technology to examine and explore the question of continous performance during darkness and nighttime. We believe that the methodology is in place for the study of these phenomenon. We are not yet clear about the form that a practical solution to these problems will take, but we are confident that our data have clarified at least the general nature of these phenomena, and therefore, we can find research tools that will help us find a solution to the practical issues.

MEMORY PROCESSES IN THE RECALL AND USE OF SPATIAL CARTOGRAPHIC INFORMATION

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The experiments reported here were carried out in the spirit of Moyer's "internal psychophysics" to explore the way in which perceptual information on continuous dimensions such as geographical area and distance is preserved in memory. Psychophysicists have long been concerned with the relationship of actual stimulus magnitude to the subjective magnitude of the sensation perceived by the observer. We were concerned here with the question of whether there is a similar systematic relationship between stimulus magnitude and the sensation magnitude represented in memory. In addition, we were interested in the relationship between perceptual and memorial judgments as an indicator of the kind of retrieval process involved. When one is asked to estimate size or distance from memory, does he retrieve a stored value directly or are additional processes involved in recall which may induce additional distortion in memory?

Experiment 1

Four independent groups of college students participated. Group one made perceptual magnitude judgments of the geographical areas of states from a map of the Continental U.S., while group two made such judgments from memory after studying a map for seven minutes. Subjects in group three made perceptual magnitude estimates of distances from the center of one state to that of another between the respective centers of the members of 22 pairs of states from a map, while group four estimated these distances from memory after studying the map.

Perceptual magnitude estimates are typically proportional to actual physical magnitudes raised to a power, i.e., $\psi = k\phi^n$ where k depends on the size of the unit of measurement. The exponent n is characteristic of the particular dimension (e.g., length, area, weight) which is judged. The perceptual exponents obtained in the present study based on group data were .79 for geographical area and 1.04 for geographical distance. For group data, log actual area was highly correlated with log estimated area (r = .99), and a similar relationship held for distance (r = .98). The exponents obtained are almost identical to those reported by other investigators using irregular polygons and lines in conventional magnitude estimation experiments with singly presented stimuli. The obtained memory exponents based on group data were .60 for area and 1.09 for distance. Log estimated area correlated .97 with log actual area, and this value was .96 for distance.

The surprisingly good fit of the power function to the memory data suggests that, like perception, memory for continuous magnitudes such as geographical distance and area is far from crude, but instead preserve some of the quantitative information present in the scale of physical stimuli. As is true for perceptual estimates, judgments of magnitude based on memory were found to be proportional to the actual stimulus magnitude raised to a power.

A "re-perceptual" hypothesis is proposed where magnitude judgments from memory are linked to the actual area or distance by two transformations. First, a perceptual power transformation takes one from the actual stimulus to the sensation and its memory representation. This is the transformation which yields the typical power function between actual stimulus magnitude and perceptual magnitude estimates. At recall, a similar re-perceptual power transformation operates when the memory representation is re-perceived and judged. Actual stimulus magnitude is raised to the same power twice, so that the exponent of the memory function is the square of the perceptual magnitude.

This schema predicts that the memory exponents for area and distance will be .62 and 1.00, respectively; these values are very close to those actually obtained. As predicted, perceptual and memory exponents were identical for distance, where perceptual judgments are directly proportional to actual stimulus magnitude, i.e., the exponent is one Perceptual and memory exponents differed for area as predicted, where a second .79 power transformation in memory was expected to compound the original .79 perceptual power transformation. As in perception, memory appears to distort judgments of relative geographic area but alters distance judgments very little. We have replicated these results using irregular polygons and lines as stimuli in a conventional magnitude estimation paradigm. Our most recent data indicate that when uncertainty and forgetting are prevalent, as in estimates made after briefly studying an unfamiliar map, substantial distortion (i.e., an exponent less than 1.0) is found for distance estimates.

Experiment 2

In our initial memory psychophysics work we focused on memory for simple visual attributes such as distance and area. We have recently extended this approach to investigate memory for spatial location on campus-sized maps as well. In one experiment, independent groups of subjects made estimates of the distance between locations on a familiar college campus or between identically arranged unfamiliar locations. For the familiar locations, estimates were made from either pre-experimental spatial knowledge (LTM condition), after studying a map (STM condition), or while viewing the map (Perceptual condition). Distances between unfamiliar locations were estimated either while viewing a map (Perceptual condition) or from memory after studying it (STM condition). Nonmetric multidimensional scaling was used to recover location information from the subjective distance estimates. In all cases, North-South and East-West dimensions emerged in the scaling solutions and the spatial configuration of points approximated the actual map. Subjects tended to "square up" the familiar rectangular map in the LTM condition, but not the STM condition. For the familiar maps, direct scaling of distance estimates showed that perceptual and memory-based estimates were compressed to a similar extent, relative to the actual distances. For the unfamiliar map, however, memory estimates were compressed or distorted more than perceptual estimates. A brief study period was thus sufficient to activate and correct a relatively accurate cognitive map in long-term memory for a familiar area, but was not adequate to learn an unfamiliar map. Hierarchical clustering analyses showed that in the memory conditions, groups of map sites tended to form separate clusters. This was strongest in the LTM condition suggesting a tendency for spatial knowledge to assume a hierarchical structure in long-term memory.

The results of this experiment were consistent with our earlier findings in suggesting that interesting systematic differences do exist between remembered and perceived maps. Furthermore, they suggest that multidimensional scaling techniques, combined with other methods, are useful for investigating spatial cartographic knowledge. However, the specific findings of this study have raised a number of additional issues. For example, does the distance estimation task provide the best assessment of a subject's remembered spatial knowledge? We addressed this question in another experiment in which subjects recalled a memorized map both by estimating interpoint distances and by sketching a complete map. An analysis of the psychophysical interpoint distance functions from these conditions revealed substantial scale compression for the distance estimation task, but remarkably accurate maps for the sketching task. This raises the possibility that certain spatial Gestalt properties of the complete map enable subjects to improve their accuracy when sketching rather than focusing on specific distances as in distance estimation.

Another question that we have addressed concerns the mental processes that subjects use to perform the distance estimation task. In other words, when a subject estimates a particular distance to be two, three, or twelve times a standard, how specifically was this number determined? We have recorded response latencies in a variety of magnitude estimation tasks to investigate this question. Our findings suggest that subjects employ some iterative comparison process in which the smaller stimulus is adjusted to match the larger.

Finally, the ultimate goal of this project is to understand theoretically how visual and spatial information is stored, accessed, and manipulated in memory. Our findings indicate that psychophysical methods can be applied fruitfully to compare memorial and perceptual processes. It is obvious that a number of unanswered questions remain, but it appears that the answers can be best achieved by an approach which searches for both similarities and systematic differences between memory and perception.

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TRAINING EXPERT DECISION MAKERS TO IGNORE NONDIAGNOSTIC INFORMATION

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Past studies of expert decision makers have consistently reported that training and experience have surprisingly little impact on the quality of the judgments made. For example, Goldberg (1959) found no difference between experienced clinical psychologists, student interns, and "off-the-street" subjects in their ability to evaluate Bender-Gestalt protocols. Similarly, Trumbo, Adams, Milner, and Schipper (1962) reported that experienced licensed grain inspectors were no more accurate than less experienced inspectors in grading wheat, but they were more confident in their judgments. Based on a review of over 20 such investigations, Goldberg (1965) concluded that "the amount of professional training and experience of the judge (is) not related to his judgmental accuracy" (p. 233).

The purposes of the present research project are (1) to demonstrate that, contrary to these earlier conclusions, training and experience can influence expert judgment, (2) to provide evidence that nondiagnostic (irrelevant) information frequently influences the judgments of experts, and (3) to develop specific training techniques to help expert judges cope with irrelevant information. An additional goal of the research is to show that Information Integration Theory or IIT (Anderson, 1974) provides a useful technique for directing and evaluating the effects of training.

The major part of the research thus far has involved taxonomic decisions made by expert agricultural judges. Specifically, two sources of evidence are relevant. The first comes from research by Phelps (1977; also see Shanteau & Phelps, 1977 and Phelps & Shanteau, 1978) on the development of livestock judging skills. Based on the number of years of formal training, 61 judges were divided into six skill levels. All judges were then asked to make a variety of judgments about each of 27 sketches of gilts (female swine). The patterns of judgments were analyzed using IIT procedures which revealed a number of developmental trends. One such trend is for less experienced judges to be more linear, while experienced judges are more interactive. Another trend is for the reliability (replicability) of the judgments to increase with experience.

The second source of evidence comes from research on professional soil scientists. Preliminary analyses revealed that soil classification decisions were frequently inaccurate in part because the presence of irrelevant materials in soil (Shanteau & Gaeth, 1980; also see Gaeth & Shanteau, 1979). A more detailed study was then run by Gaeth (1980) to compare various techniques for reducing the effects of nondiagnostic factors. Twelve experienced soil judges were asked to categorize 16 soil samples, some of which contained irrelevant components such as excessive moisture. Passive (cognitive) training sessions, involving verbal classroom-like instructions, had a relatively small influence on the impact of nondiagnostic materials. However, active (perceptual) training, emphasizing hands-on experience and self-discovery, considerably reduced the impact of irrelevant materials.

Two other findings emerged that were of considerable interest. First, a novel performance measure based on the weight given to non-diagnostic information was found to be an effective part of training. Such weight measures can be readily derived from IIT and this illustrates how IIT may be useful in specifying the direction of training (Shanteau, 1979). Second, an unexpected result was that accuracy, although non-diagnosticity impact decreased. This suggests that training to reduce the influence of irrelevant factors might be quite useful in situations where there is no criterion or "best" judgment available.

Research is presently underway on three additional experimental goals. The first is to evaluate the long-term influence of non-diagnosticity training and to determine the extent to which this training transfers to other non-diagnosticity problems. The second is to use these results to refine and develop more efficient and widely useful training procedures. The final goal is to investigate the generality in other decision making contexts of both the non-diagnosticity effects and the procedures designed to reduce those effects.

Five major conclusions can be drawn from these results. First, in contrast to previous findings, experience and training do appear to have an impact on skilled agricultural decision makers. Second, it is possible to train agricultural experts to avoid the damaging effects of irrelevant factors when making decisions. Third, active passive (instructional) cognitive training for skilled agricultural experts. Fourth, Information Integration Theory provides a helpful framework for both directing and describing the effects of training in decision making. Fifth, by training experts to ignore non-diagnostic factors, it may prove possible to increase the accuracy of judgments even in settings where there is no criterion of accuracy available.

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Learning, Memory, and Transfer

Joel Schendel

The problems inherent in developing the many diverse and complex skills of approximately three-quarters of a million Army personnel are substantial, and they are magnified by a resource-constrained environment. Nonetheless, attempts are being made to overcome them. Command emphasis is being placed on the identification of efficient procedures to train, evaluate, and maintain Army job skills. An important part of ARI' research mission is to establish a data base to support this process.

The papers presented in this section of this report describe some of the basic research funded by ARI. These research projects were designed, generally to promote a better understanding of the variables affecting learning, memory, and transfer. The research covers a variety of content areas. It includes work on conditioning (Dr. Wickens) and cognitive control processes (Dr. Weinstein). It develops alternative strategies for improved performance (e.g., Dr. Marx) for the evaluation of that performance (Dr. Newtson). Furthermore, it advances both nomothetic (e.g., Dr. Marx; Dr. Wickens) and ideographic (e.g., Dr. Notterman; Dr. Weinstein) approaches toward the study of learned behavior. Yet, while varied in content, the research was designed with one goal in mind--to help the Army meet its training needs.

ANALYSIS OF REWARD FUNCTIONS IN LEARNING

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A series of experiments in the Missouri laboratory has attempted to test the proposition that responses can be strengthened by reward in a manner that is independent of its informational function. The experiments have mainly involved comparing performance (responding, with knowledge of results) and observation (watching a paired performer respond, and receiving the same knowledge of results) in multiple-choice learning tasks. The first experiment utilizing serial tasks, showed observer superiority (e.g., Hillix and Marx, 1960; cf. also Rosenbaum and Arenson, 1968). Later experiments, with discrete (nonserial) items, revealed no overall differences between performance and observation in acquisition. However, female subjects often did better as observers, and performers--mainly male performers--tended more often to repeat both correct and incorrect responses (Marx and Witter, 1972, Marx, Witter, and Farbry, 1973).

Three recent experiments were designed to test the hypothesis that performers learn more rapidly, relative to observers, when the task is more "mechanical" (rote). This prediction was based on the assumption that a rote task offers less opportunity for the effective use of cognitive strategies by observers, and greater opportunity, therefore, for the expression of any direct strengthening by reward.

The first experiment (Marx, Homer, and Marx, 1980) gave only marginal support to this hypothesis; the predicted interaction occurred but with a $p = .08$. The second experiment, with a more systematic manipulation of the task variable, yielded a highly reliable ($p < .01$) interaction, as predicted. The third experiment did not show a reliable interaction. However, reliably more performed than observed items were acquired in all three experiments. It was concluded that these results leave open the question of some kind of more or less direct strengthening of responses, in a relative if not an absolute sense, by reward (cf. Marx, in press).

A second line of research directly addressed the role of the habit-strength concept. In order to assess the role of prior associative strength in human learning and memory, 126 high school students were first asked to give up to four verbal responses to each of 40 word cues. The responses were to be associates, so that the two terms would form a common expression (e.g., class room, mate, ring, rank). One month later the participants were given 32 words from the list as cues in a multiple-choice learning task, with response alternatives drawn from the prior responses, and two months later given retention tests. The results, in general, showed reliably stronger learning and retention of errors that had been prior response associates, compared with non-associates. It was concluded that some place needs to be made in cognitive theories of human learning and memory strategies customarily stressed. The results are especially supportive of the flexible type of response-strength concept as a complement to the learning and memory strategies customarily stressed. The results are especially supportive of the flexible type of response-strength concept (habit-activation) that has been proposed for both animal (Marx, 1966) and human learning (Marx, in press).

The learning results also confirmed an earlier demonstration of incremental response build-up over repeated occurrences of particular errors; the more often a particular error had occurred the more likely it was to recur on the next trial. Selection of the subjects with the highest frequencies of error persistence indicated that the majority of subjects did not show the effect and suggested the dependence of this phenomenon on the minority of subjects who were high-frequency error repeaters; male subjects were found to be reliably more likely than female subjects to be members of this minority.

This increased susceptibility of male subjects to persistent error repetitions was related to other results (Marx, 1979) which showed the relatively greater vulnerability of high school males to the inhibitory effects on transfer and retention of an added work requirement during learning--the scoring of performers' responses as correct or incorrect by observers. This simple scoring operation during observation was also found to result in inferior retention of conceptual learning materials in both sexes (Marx, Homer, and Marx, 1980).

Suggestions were made for interpretation of, and further research on, the error-persistence problem which was regarded as a potentially important, if generally unrecognized one, for training programs.

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THE PERCEPTUAL ORGANIZATION OF BEHAVIOR

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Three conclusions as to the nature of the process of behavior perception were presented, based upon over 40 studies of this process. The first conclusion discussed was that there exists higher-order units of perceptual information in the behavior stream that are not reducible to lower-level movement information. It was argued that task performance must necessarily consist of such higher-order action units. Consequently, observer skill training as well as task analysis should benefit from attention to this level of meaningful organization in behavior.

The second conclusion discussed was that behavior perception is an active process, and hence is variable in that it may be more active or less active. Evidence was cited showing that observers have a range of analysis levels available to them from fine units to large units. Perceived action units are typically found to vary between 1/2 and 18 seconds in length. Observers may vary level of analysis by instruction in response to situational factors like surprise, and as a result of film speed manipulations. The consequences of variation in level of analysis is increased information gain about the lower-level components of the task behavior. It was noted that this does not imply that fine-unit analysis is always best, as some evidence indicates that fine-unit analysis enhances primacy effects in judgments of series of performances. It was argued that inter-observer variability is a potent source of unreliability in observers' ratings, and that this unreliability can be countered by careful preparation and standardization of the observer.

The third conclusion from the research was that behavior perception is a highly selective process. First, the process is selective in the sense that it is less than exhaustive. Evidence was presented showing that subjects could delete up to 48% of some sequences and still comprehend the sequence as well as subjects viewing the entire sequence. The process also is selective in the sense that perceivers process available information according to some cognitive framework, or anticipator schema, so that observers with different schemata may literally see different things. Evidence was cited showing that such biases do reflect perceptual selectivity. In addition, observer skills have been found to be dependent upon such schemata, and to consist of <u>both</u> conceptual knowledge and perceptual learning. It was concluded that observer skill may be identified by assessing the segmentation of task performance, and that observer skill training must include perceptual as well as conceptual learning.

Finally, a pilot study was presented suggesting that observation skills may be important in learning from example. It was suggested that such learning may be accelerated by using techniques discovered by the present research to assist trainees in efficiently <u>seeing</u> an example.

INDIVIDUAL DIFFERENCES IN VISUAL-MOTOR ORGANIZATION

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The research program is concerned with an analysis of sensory and perceptual visual-motor organization (VMO). Sensory VMO depends mainly upon the speed and accuracy with which exteroceptive and kinesthetic information can be conjointly processed during the development of skill. The same is true for perceptual VMO, but in addition, the acquisition of skill is abetted by the greater possibility of being able to synthesize information more readily, and to plan. "Synthesizing" implies the combining of different sources of information in a way such that the result transcends the entering components, even though it depends upon them. "Planning" implies the taking advantage of whatever coherence or predictability may exist in a situation. For the present, the analysis is limited to on-going continuous behavior, such as is represented by the eye-hand, pursuit tracking paradigm of VMO. The long standing utility of pursuit tracking as a paradigm of VMO has yet to be surpassed, especially with respect to continuous behavior.

The static and dynamic, visual and motor informational components considered to be minimally necessary to affect VMO, were identified by way of two conventional equations drawn from Control Theory. For visual input (i.e., the target's momentary location), the equation is:

Position		Velocity		Acceleration
s =	+	ds/dt	+	d s/dt

For motor output (i.e., momentary force production), the equation:

Limb Displacement		Limb Velocity		Limb Acceleration
F =	K Q	dQ/dt	+	D d Q/dt

(The motor output situation was deliberately chosen to represent a quite simple force-movement transfer function, one describing a control stick loaded only with elasticity (K) through a torsion rod.)

Nine "tasks" were selected from these two equations:
Visual Discriminations--1) Judgments of differences in Target Positions (s), specified as horizontal space between successively presented pairs of points of light displayed on a Tektronix CRT 604; "% correct" was used as an index of task proficiency; 2) Differences in Target Velocities (ds/dt); and 3) Differences in Target Accelerations (d s/dt), Quasi-random combinations of spaces and times were used to determine Target Velocities and Accelerations. Temporal Discrimination--Judgments of differences in target durations (t) of successively presented pairs of points traveling the same horizontal distance, but at various speeds. Motor Actions (no concurrent visual feedback)--1) Limb Displacement consisting of angular displacement of an elastically-loaded control

stick about its axis, with both coefficient of elasticity and angle of rotation being limited to a single value of each (F = KQO); 2) Limb Velocity (dF/dt = K dQ/dt); and 3) Limb Acceleration (d F/dt = K d Q/dt). Visual-Motor Organization--1) Pursuit tracking of a target possessing predictable motion (horizontal representation of a sine wave); and 2) Pursuit tracking of a target possessing unpredictable motion (horizontal representation of band-limited frequencies).

A series of experiments still in progress permit the following summary and conclusions:

1. Individual differences among the subjects were demonstrated for each of the 9 tasks through a Test-Retest procedure, using Pearson's "r". All Test-Retest correlations were significant (p .01, 2-tailed, N=30).

2. Subjects who excel at one of these tasks are not necessarily those who excel at others. Particularly noteworthy is the lack of any sign of correspondence between proficiency of detecting differences in Target Velocities and in Target Accelerations. Apparently, the higher demand for space-time synthesis required in the latter separates the two talents. More importantly, the tapping of this cognitive or perceptual operation would seem to be devoid of educational bias.

3. Complex motor programs develop for motor actions executed in the absence of concurrent visual feedback, provided that visual cursor-target error is presented at the end of the action. The programs are complex in two ways: First, they are time-variant, or dynamic. Second, they exhibit internal corrections at points of inflection during the course of the movement even though no concurrent, external error signal is available.

4. Subjects differ significantly among themselves in their ability to acquire plans (i.e., to perform motor programs).

5. Although training in Pursuit Tracking significantly improves performance, and is therefore vital to efficient VMO, subjects array themselves reliably the same way at the end of training as they did at the beginning. This phenomenon is especially strong for pursuit tracking of a target in predictable motion, where--after 10 sessions of training--the correlation between initial and final performance is sufficiently high to be acceptable at p .01, 2-tailed, N = 9. More subjects are being run.

6. Throughout the series of experiments, the influence of perceptual synthesis and organization is in evidence. The research shows how training and performance depend upon entering components of space, time, and action; but it shows just as clearly that cognitive and perceptual operations transcend the fundamental components, and that individuals differ significantly in their capacity to utilize these operations. Further, it is reasonable to hypothesize that the cognitive and perceptual operations involved are free of any educational background.

7. Collectively the findings would appear to have direct implications for personnel selection, training, and performance.

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COGNITIVE LEARNING STRATEGIES AND STUDY SKILLS TO IMPROVE RETENTION

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Providing high-quality instruction is a necessary process/objective for meeting the goals of the military services. Given the high cost of teaching technical job skills to members of the Army, it is important to consider alternatives that increase the effectiveness, or reduce the cost, of current training practices. One alternative that could improve the ability of service personnel to learn from instruction and on-the-job experience is to teach them a broad range of learning and study skills. There are at least two ways to proceed toward this objective given current training needs and the existence of extensive training materials and systems. The first approach would involve developing independent training programs to teach learning strategies and study skills. The programs could be administered individually, or in combination, prior to basic or job-related training. The second approach would involve prompts that could induct the trainees to use appropriate learning strategies and study skills to learn job-related tasks. This latter approach avoids asking trainees to learn seemingly irrelevant techniques in preliminary instructional sessions where no immediate utility for the skills is apparent and may avoid the problems of transfer to job training, but it also entails costly and extensive revisions of the instructional materials now in widespread use.

There is no optimal resolution for this dilemma, but the first approach, developing independent training programs, seems the most reasonable alternative given current resources and the state-of-the-art knowledge in this field. Interest in the nature of learning strategies and optimal training methods in their use is increasing among both researchers and practitioners. To revise the technical training materials used by the Army at this point in time would be premature. The development of independent training methods and materials to teach learning strategies would provide a means for taking advantage of current knowledge in this field as well as providing a means for cost-effective up-dating of this instruction as new data becomes available.

Part of the purpose of the Cognitive Learning Strategies Project, located at the University of Texas, is to identify and study a number of the cognitive competencies needed for effective learning and retention, particularly imaginal and verbal elaboration, and to investigate the means needed to identify and train less successful learners in the use of these competencies or strategies. The use of study skills to organize new material to facilitate the use of acquisition and retention also is being investigated.

Although many educators and psychologists agree that successful learners use a variety of effective elaboration strategies to organize and execute any particular learning act, the types and essential components of these strategies have not been systematically identified or classified. Previous research on the training of cognitive strategies has been based on the experimenter's conjecture about what constitutes an effective cognitive strategy rather than on broad-based evidence gathered from a large number of successful learners. As part of this project, a series of exploratory studies were conducted with 4-year and community college students to develop the Learning Activities Questionnaire which has been used to gather information about the use of learning strategies by people in different settings and at different educational levels. There are seven different settings and at different educational levels. There are seven different learning activities that serve as stimulus materials for the questionnaire. These tasks had elicited the greatest range of different learning methods in earlier developmental studies. These activities include three paired-associate learning tasks, two free recall tasks, and two reading comprehension tasks. Learners are asked to study each of the learning activities and then respond to a series of open-ended questions about the methods they might use to remember the material.

Data have been gathered on the types of strategies used by graduate students, community college students, and three groups of Army recruits possessing either a high school diploma, a general education diploma, or no diploma. The strategies were synthesized into five different categories.

These were:

1. Rote strategies--strategies that emphasized repetition;

2. Physical strategies--any strategy that involved using the physical properties of the material to be learned, such as spelling patterns;

3. Imaginal elaboration--any strategy involving the formation of a mental picture in order to learn the material;

4. Verbal elaboration--actively working with the material by asking and answering questions about it, determining implications of the content, relating it to information already known, etc.;

5. Grouping--rearranging the material to be learned into smaller subsets according to some perceived characteristic that is commonly shared.

The patterns found in the data are fairly consistent. Both college student groups reported using a variety of strategies. The graduate students reported a greater number of verbal and imaginal elaboration strategies than the community college students, but both groups also reported using a number of less effective rote strategies. The noncollege groups reported using fewer types of strategies than any of the college groups, and many of the recruits in these groups reported using no strategies or only rote strategies. We are currently conducting two studies to investigate further the specific properties of imaginal and verbal elaborators that make them effective learning aids.

In a preliminary study designed to investigate these issues, a number of different cognitive strategies, learning tasks, and stimulus materials were used to train ninth graders in the use of generalizable elaboration skills. The cognitive strategies, drawn from the research literature in cognition and instruction, included various forms of verbal and imaginal elaboration. The use of elaboration requires the learner to create a symbolic construction that, when combined with the new to-be-learned infomation, makes this information more meaningful. For example, when learning from text, the learning could relate the material to previous knowledge directly, by forming a visual image, or by creating an analogy. The learning activities included traditional laboratory tasks, such as paired-associate learning, and everyday school tasks--such as reading comprehension. The learning materials were selected from appropriate curriculum materials in a variety of academic disciplines.

Seventy-five ninth grade students were randomly assigned to one of three groups: training/experimental, control, or post-test only. The experimental group participated in a series of five one-hour elaboration skill training sessions, administered at approximately one-week intervals. Students were exposed to a set of 19 learning tasks. They were required to create a series of elaborators, or mediational aids, for each of these tasks. Experimenter-provided directions for the early tasks emphasized the properties of an effective elaborator. The latter training sessions provided opportunities for additional practice in using these skills with little or no experimenter-provided instructions. The control group was exposed to the same stimulus materials but their task was simply to learn the information without any type of strategy prompts or directions. A post-test only group was not exposed to the stimulus materials but did participate in the post-test sessions. The immediate post-test was administered one week after the conclusion of the training, and the delayed post-test was administered approximately one month later. Both immediate and delayed post-tests consisted of reading comprehension, free recall, paired associate, and serial recall tasks.

The results of the data analyses for the immediate post-test revealed significant differences between group means on the free recall and Trial 2 of the paired-associate learning tasks. In each instance, the experimental group's performance, surpassed the performance of the control and post-test only groups, which did not differ significantly from each other. On the delayed post-test, a significant difference was obtained for the reading comprehension task and Trial 1 of the serial learning task. Again, these differences favored the experimental group. It seemed that students could learn to utilize these elaboration strategies in a variety of task situations but further research was required to determine the optimal conditions for their learning and use. We are currently conducting several training studies to investigate further these issues.

In addition to verbal and imaginal elaboration, a number of other competencies necessary for effective learning and retention have been identified. These competencies include the use of organizational skills, such as time management and efficient study procedures, and self-management skills, such as anxiety reduction, concentration and focusing on the task. In the past, these various competencies have usually been studied in isolation from each other, rather than focusing on their similarities and differences with an emphasis on how their several effects might interact in a total learning situation. It seems reasonable that a combination of these skills may prove more effective in enhancing learning than any one in isolation. Students could then be taught diagnostics for the application of particular skills or combinations of skills. This could be a unique and critical contribution to instructional theory and practice. A study is currently underway with four sections of an undergraduate course in individual learning skills to investigate this issue.

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INVESTIGATIONS OF COGNITIVE CONTROL PROCESSES IN CONDITIONING

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Two types of situational demands may be contrasted with each other. In one class of situation the subject is allowed time for thought, making a decision of whether or not to respond and what response to make. Contrasting with this situation is the one which demands prompt action with little or no option on the nature of the response which is permitted and which is to be made. The two classes of responding are each appropriate to their own physical and social environment. In some situations the ultimate survival of the individual or his social group demand unquestioned responding, while in others the more leisurely and pondering approach makes its contribution to survival.

Although there are many gradations between the two extremes, the conditioned response (CR) is generally considered to be of the latter type. Skinner called it a respondent specifically stating that the response is elicited by the conditioned stimulus(i). The CR involves more than knowing that A will be followed by B at some set temporal interval; it involves also making a B-like response prior to the occurrence of that stimulus. Pavlov uses the term "reflex" for this kind of learning.

The psychological interpretation of classical conditioning has two extreme interpretations about its nature and execution. The strong cognitive view is that the subject has learned that B is likely to follow A, and then decides whether to respond or not to respond. The other extreme, as implied by Skinner and Pavlov's terminology, is that the CR is both automatic and mandatory. Stated simplistically, the second view would hold that acquisition and execution are solely a function of environmental manipulation, whereas the first view implies the occurrence of subject-generated strategies in both acquisition and execution. In one instance, both acquisition and execution could be called voluntary and in the other involuntary. It seems likely, however, that some intermediate and variable position is the more likely state of affairs, and that acquisition, and possibly, execution are influenced not only by environmental manipulations but also by cognitively manipulated factors. The current research was designed to assay the role to cognitive factors in the acquisition of a CR.

The experiments utilize the sensory pre-conditioning paradigm. In this situation two neutral stimuli are paired together for a number of trials, then one of these stimuli is paired with an effective unconditioned stimulus (UCS) to establish conditioning. Finally, the other stimulus is given to determine whether the CR has been acquired to that also, even though it had not been physically associated with the UCS. There has been an abundance of research showing that this will happen.

The experiments. The rationale of this experimental program was to manipulate the cognitive variable while keeping the physical conditioning situation constant, using the sensory pre-conditioning paradigm. The cognitive manipulation applied to the pre-conditioning period and consisted of telling the subjects to think of the two stimuli--light and tone--as being alike (pro group), as being different (anti group), or that the stimuli were presented only to adapt them (neutral group) to the stimuli. Clearly the question being asked was whether these instructions influenced sensory pre-conditioning.

Experiment 1. This experiment consisted of four phases and of six groups of 30 subjects each. In phase 1 instructions about the experiment were given, including the cognitively biasing ones, with 60 subjects being given the pro, neutral, or anti instructions. Phase 2 was a sensory preconditioning session for half the subjects and a sensory pre-conditioning control for the other half. The experimental groups, hereafter referred to as paired, received the two stimuli--light and tone--paired, with the onset of one preceding the other by 500 milliseconds (ms). In the control condition, hereafter called unpaired, these stimuli were given randomly always being separated by at least 12 seconds. Each third of the unpaired and paired groups had received a different set of instructions--pro, anti, or neutral. In phase 3 the second of the paired stimuli became the CS for a shock UCS. The response measured was the Galvanic Skin Response (GSR). (The unpaired CS during this stage matched the appropriate modality of the paired groups, and modality was counterbalanced). Phase 4 consisted of giving the other stimulus alone for 10 trials without shock--a test for sensory pre-conditioning.

The results for the paired groups showed an instructions effect, with the pro group being superior to the neutral and the anti group, and the latter was inferior to the neutral group. However there was no difference among the unpaired groups as a function of instructions, and they all were inferior to the pro and neutral paired groups, but did not differ from the anti paired group. Stated in general terms, instructions are effective in sensory preconditioning only if they are associated with a supporting environmental condition.

Experiment 2. In this experiment, the topic of pro and anti instructions was once again investigated under conditions favorable or unfavorable to sensory pre-conditioning. The independent variable was time relations in the sensory pre-conditioning stage. For one instructional pair of groups the sensory pre-conditioning test stimulus was the first stimulus of the pre-conditioning pairing (Forward); for another it was the second stimulus of pre-conditioning (Backwards), and for both of these groups the onset differential was 500 ms, a presumed optional interval for forward conditioning. For the next set of groups the pairing during the sensory stage was one of simultaneous onset of the two stimuli. Each of these time intervals contained a pro and an anti group. An unpaired, neutral instructed group was used as a basic control. The logic of the experiment was that sensory pre-conditioning should be readily obtained for the forward group, negligible for the simultaneous group, and absent for the backward group. The question being asked was whether or not pro instructions would eliminate the environment differences.

Except for these differences, the procedure was the same as in the first experiment with the same four stages. Again there were 30 subjects in each group. The statistical analyses indicated that the only group which excelled the random control group was the pro forward.

The data of both experiments clearly indicate that this particular cognitive manipulation cannot substitute for the appropriate training procedure. Stated in another way, one cannot make a silk purse out of a sow's ear. The data of the first experiment do show, however, that, given a favorable cognitive impetus and the appropriate learning situation, acquisition can be facilitated. They suggest that the most efficient training procedure is one which employs not formal training alone, but one which has this training preceded by an appropriate vicarious experience.

The research now in progress follows the same general schema as the ones reported above but measures simultaneously the autonomic response (GSR) and the skeletal (voluntary) response of finger withdrawl.

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Human Relations

Glenda Y. Nogami

The Army has always evidenced a strong concern for leadership. Leading soldiers and managing their individual and group performance are two major aspects of an NCO or officer's job. The papers presented in this section reflect the range of research supported at ARI.

Thomas Milburn's presentation deals with crisis management. He is currently investigating the various dimensions of crises and leader responses to determine what kinds of responses are more effective in what kinds of crises.

Alan Harris reports on three experiments which investigate the effects of organizational structure and leadership factors in sustained group performance. Harris is concerned with the group's social structure as well as their ability to perform tasks.

David Herold presents an interesting proposition in his paper: He proposes that group performance experiments should consider the tasks used. Herold hypothesizes that effects attributed to groups may, in fact, be better attributed to the specific tasks involved.

Terence Mitchell presents the other side of performance--research on poor performance. His research has applied the internal-external dimension of attribution theory and developed a model for diagnosing and responding to poor performance.

ORGANIZATIONAL STRUCTURE AND LEADERSHIP FACTORS AS DETERMINANTS OF SMALL GROUP PERFORMANCE

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Where sustained and accurate performance on a complex duty assignment for days, weeks or longer is critical to the successful outcome of a given mission, it is obviously essential to know how best to arrange individual and/or group living and work routines to promote maximum performance effectiveness and maintain high morale throughout the mission's duration. It is thus necessary to know the most effective organizational structure for such operational units and to understand the interacting leadership factors which in concert determine both performance maintenance over extended intervals and the day-to-day status of the group as a social system.

For the most part, the voluminous research literature on organizational structure and leadership which has developed over the past two decades (for reviews see Shaw, 1971, Hare, 1976) is characterized by one or the other of two investigative restraints which limit the generality of experimental findings. On the one hand, studies which have focused upon ongoing operational settings (e.g., industrial and/or military groups) in the natural ecology have been limited by the lack of control which can be exercised for the purposes of manipulating critical experimental variables. On the other hand, laboratory situations which offer the opportunity for required experimental manipulations have seldom provided for extended residential intervals of observation and objective recording under realistic and naturalistic incentive conditions for a broad spectrum evaluation of performance effectiveness and morale in small operational groups. The continuously programmed residential environment approach represents an attempt to circumvent these evident limitations on organizational structure and leadership research with small groups.

Groups of male and female volunteers recruited from local college student communities served as experimental subjects in these studies. All subjects received psychometric test evaluation and interview assessment by a staff psychologist as part of the screening procedure of acceptance as participants in the experiments. Each subject was fully informed about the research setting and procedures, which included several daily briefing sessions in the programmed environment preceding the start of an experiment to insure familiarization with the operational features of the laboratory. Following these briefings, but before beginning an experiment, a written informed consent agreement was signed and exchanged between the subjects and experimenters. In addition, a manual of instructions detailing the experimental procedures and environmental resources was provided each subject for guidance throughout the experiment. The subjects in experiment I were three males ages 34, 23, and 21. The subjects in experiment II were three females ages 32, 24, and 29.

In the first experiment, three male subjects lived for 48 consecutive hours in a continuously programmed laboratory environment. During their residence, the subjects could earn money by performing on any of four work tasks that were concurrently available. The four tasks were: 1) the Alluisi Performance Battery, 2) serial acquisition task, 3) lever pulling, and 4) physical exercise. Monies earned on these tasks during the odd hours of the day (e.g., 1 o'clock, 3 o'clock, 5 o'clock, etc.) accumulated in the bank account of the individual responsible for the earnings, while monies earned during the even hours of the day (e.g., 2, 4, 6, etc.) contributed to a group bank account in which each participant held a 1/3 share. Thus, monies earned by work performance were deposited to one or the other bank account (group or individual) depending upon which hour of the day the work was done. At the end of the experiment, subjects received all the money in their individual account plus 1/3 of the money in the group account.

In addition to earning money, subjects could lose some of their earnings according to the following rule. Two of the work tasks, the Alluisi program and the serial acquisition problem, were presented via a CRT screen that was displayed continuously during the 48 hour period of the experiment. During the last minute of every hour however, the display was programmed to turn off and the subjects (any one of the three) were required to report this event and thereby reinstate the display. Failure to detect and correct the dark screen condition (within one minute) would result in halving (50% reduction) of the accumulated sum of money in one or the other bank accounts. Failure for each one minute that a dark CRT screen went unreported at the end of even hours of the day resulted in a 50% reduction of the total amount in the group bank account, while failures to report a dark CRT screen at the end of odd hours of the day resulted in a 50% reduction (per minute unreported) in the individual accounts.

Thus subjects were required to maintain this 48 hour monitoring of the CRT display in order to protect their earnings from any loss. Throughout the experiment subjects could audit the totals in all bank accounts.

The principal experimental questions asked in this experiment were: 1) How would the group share the responsibility for maintaining vigilance of the CRT display and thereby avoid any monetary loss? 2) How would individuals apportion their work effort with respect to individual versus group earnings?

Experiment II was identical to Experiment I with the single exception that the subjects in Experiment II were three females.

In Experiment I, the three male subjects cooperated in maintaining a continuous watch of the CRT screen and correctly detected all interruptions of the task display, thereby preventing any monetary loss from either the group or individual bank accounts. This cooperative effort involv[illegible] a rotating schedule of "on duty" responsibility with each participant serving a 3-4 hour on, 6-8 hour off cycle.

With respect to earnings however, all three male subjects exhibited a much greater self interest rather than group effort, with each subject earning much more money for their respective individual bank accounts than they did for the group bank account. This was accomplished by work efforts bein[illegible] disproportionately distributed in favor of the odd hours of the day. Specifically Subject (1) earned $71 for himself versus $36 for the group, Subject (2) $65 versus $23, and Subject (3) $64 versus $30. This separation of effort was apparent for Subject (2) as early as the first few hours of the experiment while for the other two subjects, the significantly greater work effort for individual accounts did not emerge until 20-24 hours later.

In Experiment II, the three female subjects also maintained a continuous watch of the CRT screen and correctly reported all interruptions of the display. Consequently, as with the male subjects, no money was ever lost from either the group or individual bank accounts. The women's on-off duty cycles were somewhat shorter however, than the men's with the women averaging 2-3 hours on and 4-6 hours off. With respect to earnings, two of the female subjects earned approximately equal amounts for the individual and group bank accounts while the third female subject from the outset showed the self interested earning pat[illegible]n of the three male subjects. Specifically, Subje[illegible] (1) earned $40 for [illegible] versus $40 for the group [illegible]ubject (2) $58 versus $12, and Subject (3) [illegible]sus $36.

Within each [illegible] of subjects the followi[illegible]eneral rule applied: The lower the total earnings (individual + group) [illegible]ater was the proportion of earnings for the individual account (individual + individual + group). In both groups of subjects, morale was high, interpersona[illegible] relationships [illegible] pleasant and during debriefing, all subjects' comments were uniformly positive as they expressed their enjoyment of the experiment and their feelings toward their co-participants.

In Experiment I, although the men cooperated in maintaining the avoidance of monetary loss, their work efforts were clearly biased toward their personal earnings. By way of explanation, it may be postulated that by working for themselves, earning amounts were "guaranteed" whereas work efforts for the group were proportionately rewarded only if matched by equal work efforts of the other group members. From an individual's point of view, the relative uncertai[illegible]y of gro[illegible] performance and thereby i[illegible]dividual contributions and shares in the gr[illegible]p tot[illegible] can be viewed as one reason for this outcome. Furthermore, the early emerg[illegible]ce of self interested performance by one subject can be seen to confirm this potential imbalance for the remaining subjects and set the example for their performance during the remainder of the experiment.

The outcome of Experiment II however, revealed that two of three female subjects did not work significantly more for their individual earnings despite the fact that one female worked proportionately even more for herself than did any of the male subjects. These data suggest first that the self interest outcome of this experimental situation is not inevitable nor does the example set by one individual necessarily serve as a model for emulation by the other participants. Taken together, the data from these experiments suggest a sensitive procedure for revealing self interest vs. group oriented behavior in a residential laboratory setting. Ongoing experiments focusing upon such variables as sex, personality, and payoff matrices should clarify the role of these variables in determining the outcome of these socially relevant behavior processes.

A third (10-day) experiment in this series has been recently concluded, and the data from that experiment are currently being analyzed. Preliminary examination of the data, however, revealed: 1) the consistent and successful use of a newly introduced temperature self-regulation task; 2) a stable pattern of intersubject synchronization which resulted in equal sharing of work opportunities and approximately equivalent daily earnings; and 3) a resistance to the effects of competitive vs. cooperative incentive conditions when alternated on a 24-hour schedule. The data from these experiments suggest that conformity to a rule depends not only upon the nature of the rule itself, but also upon its temporal parameters and the extent to which these parameters match or correspond to the temporal size of everyday work and rest activities.

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A TASK-BASED FRAMEWORK FOR UNDERSTANDING AND IMPRO ING GRO PERFORMANCE

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Background

nt re iew of the relationships between group performance and those maje les usually investigated for their effects of performance, (Nieva, Fleis and Kieck, 1978) concludes with a summary of 12 propositions concerning these relationships. Nine of these propositions are qualified by a st ement or realization that task-type is a likely moderator of the relationship proposed. This inability to offer straight-forward propositions about group or contextual characteristics as they affect group performance, without first accounting for task effects, has been repeatedly noted (e.g., Hackman and Morris, 1975; Steiner, 1972). It is generally agreed that this task-centered dilemma is largely the result of the inattention which researchers have shown towards this critical variable (e.g. Hackman and Morris, 1975; Zaj nc 1965). Tasks in group research have been haphazardly chosen, have been unsystematically varied across studies making comparisons of findings difficult, or have been tightly controlled and narrowly specified within studies such that we do not know the extent to which the effects studied are task-bound (See Hackman, Brousseau & Weiss, 1976, for a rare exception). This lack of generalizability, or incomparability of previous research efforts has been demonstrated by writers who have shown that seemingly contradictory findings of different studies investigating the same variables or relationships could be reconciled if one accounted for task differences between these studies (e.g., Herold, 1978; Shaw, 1954).

Present Effort

The present research effort builds on observations and has as its major focus an attempt to develop a task taxonomy which could be used to: a) specify the types of tasks for which certain relationships hold, b) identify the process issues which seem to be related to successful performance of different types of tasks, and c) could serve as a guide in choosing strategies for on group performance by identifying task-contingent process iss are likely to be related to group task performance.

h and Altman (1966) note four approaches to task description. Two of these, "task qua task" and "task as behavior requirements" are utilized in the present approach. The task qua task approach has been critized as being too open-ended and not necessarily linkable to group interaction process. However, as Altman (1966) notes this criticism could be overcome if we first identify the basic behavior requirements created by tasks and then proceed to identify only those task-descriptive dimensions which are related to these behavior requirements. Using this approach, the present line of work (Herold, 1978; 1979) has proposed a distinction between the technical and social demands made by tasks, with each of these demand dimensions varying on a dimension of complexity (i.e., easily satisfied or difficult to satisfy). Thus we have a four-celled typology, with tasks being socially simple or complex and technically simple or complex, depending on the process demands which they impose on the group.

Earlier attempts at using this typology for making rather clinical assessments of task-types have been successful in reconciling previously contradictory studies on the effects of different change strategies on group performance (Herold, 1978), and have also been shown to lead to empirically supported propositions about the effects of certain leadership training strategies on the performance of groups performing different tasks (Herold and Wolf, 1977). Viewing these efforts as dealing with the "task as behavior requirements" approach to task description, and having demonstrated that the presently used dimensions are reasonable for assessing behavior requirements at a gross or macro level, the following steps are presently being implemented to further these developments:

1) An effort is being made to move to the "task qua task" mode by identifying specific task atrributes which are expected to give rise to the socially simple or complex and technically simple or complex process demands.

2) The utility of the task typology is being tested by examining the feasibility of categorizing actual work-group tasks according to the identified task attributes, and testing the reliability or consistency of such classification within organizations but across individuals.

3) These attributes, to be maximally useful, will have to be linked to specific behavioral expectations which are more micro than simply "social" or "technical" process episodes. That is, we need to determine what it is that we expect the group would have to do to satisfy a demand created by a specific task attribute (for example, if solution multiplicity is a relevant task attribute then one could observe whether or not the group has recognized this by generating and evaluating multiple alternatives).

4) While task characteristics are hypothesized to create social and/or technical process difficulties which need to be satisfied in order for affective task performance to take place, it is probably safe to assume that other individual, group, and contextual variables will also be responsible for creating or modifying process demands which the group must deal with. For example, the nature of members' skills, group norms, and organizational reward systems can be expected to create or ameliorate social and technical process difficulties above and beyond what has been predicted by the task analysis. Towards this end, the present effort is also aimed at identifying these relevant other variables which, together with task influences, determine what will actually take place during group process, and whether or not this will be adequate for meeting task demands.

Implications

If successful, the above efforts will have both theoretical and applied implications. Theoretically, these developments will hopefully allow us to better understand the role of tasks in research on group performance, to proceed with research efforts which are more cumulative and integrative than the present patchwork of studies, and to better understand previous research efforts. Another potential theoretical benefit would be the closer linking of research on group characteristics, group performance, and group process.

In terms of applications, to the ent that these efforts will be able to identify the sources and nature of process difficulties which possibly inhibit group performance, they will make possible tests of the effects of group intervention strategies specifically chosen or developed for the purpose of addressing such task and/or situation v determined process difficulties. Current group intervention strategies ar. rgely technique and/or normatively-based and their application across groups performing different tasks has resulted in mixed results at best (e.g., Herold, 1978). It is assumed that task-contingent applications of such strategies will be more successful in improving t. task-performance of groups.

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A STUDY OF LEADER BEHAVIOR IN THE EFFECTIVE MANAGEMENT OF ORGANIZATIONAL CRISES

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ABSTRACT

Several questions arise concerning orgainzational crises and their handling:

1. What is the nature of crisis in organizational settings; are taxonomies appropriate?
2. What kinds of responses occur?
3. Which are adaptive or effective responses?
4. What practical applications are there?

This paper reports on research efforts to conceptualize, measure, and understand aspects of crises in organizations--and to develop hypotheses and insights. The program of research included laboratory and field experimentation, a questionnaire-based survey, and a dozen cases investigated by multiple interviews and observations.

Organizational crises are decision-making and -implementing situations. It is necessary for them to be perceived as crises by key individuals within organizations in order to be treated and responded to as organizational crises. Organizational crises always involve some degree of stress upon individuals within the organization. Stressful situations, whether of constraint, demand, or opportunity claim adaptational energies from individuals in their interactions with their environments. Humans are maximally adapted to effective internal and external performance within a number of physical and psychological parameters; outside of these, it is more difficult for persons to maintain homeostasis, and stress symptoms develop. Stress may arise from various physical conditions (temperature too high, temperature too low, too much or too little noise or light or other stimulation) and from psychological ones (threats of loss or danger, action demands-especially ones with deadlines, uncertainty or unpredictability, and lack of control). The effects of stressors cumulate additively over situations and time (Holmes & Rahe, 1967). Older persons show similar sympathetic nervous system responses (fight-flight) and extensive chains of hormonal and other responses, as do younger ones, but slower decline in blood pressure, pulse rate, etc. after the stressors are no longer present (Levi, 1979). Individuals show large differences in their perceptions of the significance and severity of the stressful conditions they face. Type A persons are very time-sensitive and -responsive, and stress themselves and others under conditions in which they perceive time pressure.

Our research investigations have led us to a new definition of crisis; namely, that an organizational crisis is a situation (a threat or opportunity) involving a high probability of significant loss to the organization, and where there is perceived time pressure to resolve it. Somewhat to our surprise it is not so much unexpectedness or surprise <u>per se</u> that exacerbate crises but rather a lack of articulated plans, or practice-based relevant skills and access to necessary resources. Time pressure appears to intensify crises. Organizational crises produce chains of individual crises as managers, sometimes inadvertently, stress their subordinates. Crises to which we have attended have very often, though not always, worsened as a function of top management needs to centralize control and to leave out middle-level managers and experts and the information these people could have provided. [illegible] may differ as a function of whether the crises are seen as emerging from [illegible]de or inside the organization. Outside threats are more readily managed [illegible] internal ones, and may lead to increased organizational cohesiveness if they [illegible] used to mobilize efforts inside and to give additional meaning to the tasks employees perform. Internal threats may fragment parts or levels of an organization and may lead to a residue of ill will and conflict.

In the only instance in which we could observe two crises simultaneously in the same organization, there was a loss to part of the organization--a complete change in the top management team, actually--that appeared and still appears to have been quite preventable except that the attention of the leadership was focused on an opportunity, going public and being able to make an important merger. As a result, necessary efforts to acquire financial and political allies were not taken in time to prevent the take-over.

A degree of detachment would appear to be invaluable in dealing with crises whether this comes from good planning, from having an emergency role, from being a slightly less involved (and certainly less threatened) expert, or from the emotional inoculation of having faced and mastered some past crises (Janis & Mann, 1977), ideally rather different or even simulated past crises. Managers who have created crisis situations for others in the organization by the demands they make may feel detached. Virtually all those in a variety of organizations who worked in crisis situations but found themselves detached or distanced from the danger, or who felt themselves in control of the situation reported their crisis experiences to be exciting, pleasurable, exhilarating, and meaningful. Moreover, they were most likely to report themselves and to be described by others as performing effectively during the crisis.

Planning and past experience would seem most useful preparation for crisis performance. Past experience perhaps could include experience in simulated crises in which task demands, threats of appraisal, and time pressure provide useful analogs of real-world crisis situations. Simulations can dramatically illustrate the importance of not getting caught up in local worst-case analyses and definitions of the situation as well as providing some experience with the necessity for planning for access to needed resources, i[illegible] allies. Simulations may provide emotional inoculation, but they can also provide training and experience in appropriately monitoring the events in crisis situations.

There are other ways of thinking about dealing with organizational crises in effective ways. Surely not the worst of these is frequently the military way, cleaning out management. Such action has most often taken place during the first six weeks after the United States has gotten into a major war in which the costs and potential costs of errors could influence victory. Some kinds of mistakes one does not want to see made twice. Mistakes do not occur merely out of carelessness or incompetence, of course, but because some persons are simply less effective in stressful situations such as organizational crises. Not only striving rigid people, but particularly defensive ones, anxious ones, self-critical ones with low self-esteem, and often angry ones, or ones who respond hyperbolically, appear less effective in crises. As Fiedler and his colleagues (1980) have observed, experience appears more useful than intelligence for dealing with crisis situations.

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DECISIONS ABOUT CAUSES OF POOR PERFORMANCE

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What happens when a manager or supervisor observes or is informed of a subordinate's performance? That is, given that the leader has knowledge of the problem how does he or she proceed to remedy it?

The literature (up until recently) related to this question has been rather sparse and tends to be of a descriptive or personal experience nature. There seems to be agreement that certain violations demand an immediate and punitive response. For example, theft, falsification of re ort fighting reprimands, probation and/or termination.[1] In many cases this response is dictated by company policy and the supervisor really h s ver little discretion over what happens.

However, most cases are not so clear cut. What usually happens is that a subordinate misses a deadline, is tardy or absent occasionally, does not work overtime when needed, engages in horseplay, does sloppy work or some other less extreme violation of expected behavior. The task of the supervisor or manager is more complex in these settings, simply because there are few clear prescriptions or rules about how to proceed.

Probably the first thing that happens in cases for which no clear policy exists is that the supervisor tries to determine why the behavior occurred. In trying to ascertain the cause of the poor performance, the supervisor may solicit information from a variety of sources including the subordinate in question. After this information is gathered, it must be processed, sorted, and evaluated and eventually some sort of reason or reasons are judged to be the contributing factors. For example, the poor performance might be due to a low skill level, a lack of motivation, poor instructions or insufficient support services. This process is called the attribution phase.

After the cause is determined, the supervisor will usually select some course of action that fits the believed cause. So, for example, if the subordinate's poor performance is seen as being caused by low motivation, the supervisor might engage in a formal discipline procedure and verbally reprimand the employee. If, on the other hand, the reason is seen as insufficient information or support, the supervisor might institute changes in the work setting and if ability is seen as the cause, training might be appropriate.

There are two key points about the process described which need to be highlighted. First, it is a two stage process. There is an attribu phase where the supervisor determines the cause of poor performance, a is a decision phase where a response is selected from a set of alternat Second, we must recognize that this process entails active information pr cessing on the part of the supervisor. Therefore, simply ving good performance appraisal instruments or prescribed disciplinary procedures is not enough. In order to understand what is happening and how poor performance can be handled more effectively, we must understand this evaluation process more fully.

A Model of Diagnosing and Responding to Poor Performance

The model which is presented in the symposium is designed to represent the two stage process described above. For both of these stages there are some rational factors and some biases that affect the leader's judgments.

There are three information dimensions which help the leader decide between an internal cause (e.g., effort or ability) and an external cause (e.g., a difficult task, bad luck). Distinctiveness refers to the extent to which a subordinate has performed poorly on other tasks. The less distinctive, the more likely an external attribution. Consistency refers to the extent to which performance has been poor before on this particular task. The more consistency, the more internal the attribution. Finally, consensus refers to the extent to which other subordinates perform poorly at this task. The lower the consensus, the more internal the attribution. For example, a subordinate who has done well on other tasks (high distinctiveness), done well on the particular task in the past (low consistency), and has co-workers who also have difficulty with the task (high consensus) is likely to receive an external attribution.

Besides these rational informational cues there are lots of other factors that influence the attribution, and many of these factors introduce bias into the process. First and probably most important is the actor/observer bias. It has been well documented that people think their own behavior tends to be caused by external forces but that the behavior of others is caused by internal factors. The behavior of someone else is salient to the outside observer, but it is the environment which is salient to the actor. So, a subordinate (actor) explaining the causes of his or her behavior is likely to see it as caused by external events while the supervisor (observer) is likely to see it as caused by internal dispositional factors.

Coupled with the actor/observer error are some self serving biases. In general people tend to attribute successes to themselves and failures to forces beyond their control. When we combine these two biases, we can see that in cases of poor performance it is very likely that supervisors will see the causes as internal to the subordinate, while the subordinate will see the cause as external events. This difference in attributions is likely to lead to conflict, disagreement and hard feelings.

There are some other sources of error in this attribution phase. Anything that increases the distance (psychologically and physically) between the supervisor and the subordinate is likely to increase actor/observer and self serving experience he or she has with the subordinate's job, and the more power the leader has, the more the supervisor is likely to make internal attributions for poor performance.

The second link in the model is the decision phase--the leader must select a response. Obviously, if an internal attribution has been made, the response is likely to be directed at the subordinate (e.g., reprimand, training) and if an external attribution is made, a response directed at the task will be more appropriate (e.g., provide more support, change the task). Again, there are some rational and less rational factors that affect this response.

On the rational side is the fact that supervisors at this point usually engage in some sort of cost/benefit analysis. That is, they weigh the pros and cons of various responses. They consider such factors as what is the probability of a given response (1) changing the subordinate's behavior, (2) having a positive or negative impact on other employees, (3) making the supervisor feel good, (4) adhering to company policy and so on. These are clearly important inputs to the decision.

But, again, there are some less obvious factors that seem to enter in. For example, there is now considerable evidence that the consequences of the poor performance affects the response by the supervisor. If the missed deadline for the financial report results in a lost contract, the supervisor is much more likely to be personal and punitive than if nothing negative occurs. In many cases, the subordinate may have no control over the outcome, but yet he or she is treated much more severely when something negative happens than when nothing negative happens.

Another source of bias in the response phase is likely to come from the subordinate in the form of apologies, excuses and external explanations. Even though the supervisor has accurately diagnosed that a subordinate performed poorly because of low motivation, he or she is much less likely to be punitive and severe if the subordinate apologizes and promises it will never happen again. It is simply hard for a manager to be severe and punitive with someone who admits their mistake.

If one summarizes the implications of what goes on in the two phases we have described, the following conclusions emerge. First, supervisors are likely to see the poor performance of subordinates as internally caused. Second, there is likely to be disagreement about that attribution. Third, there are forces along with the internal attribution (such as outcome knowledge and ease of use) which will push the supervisor towards a personal, punitive response. However, apologies and social or organizational constraints may make it difficult to actually utilize such responses. Thus we are faced with a situation where a supervisor, first of all, may unknowingly make some errors of judgment about the causes of poor performance, and then secondly feel frustrated because of certain social or organizational prohibitions about what he or she feels should be done.

One final point needs to be mentioned. There are times when the above process is not used. More specifically, there are certain situations where there exists either a personal or organizational policy to deal with poor performance (e.g., three unexcused absences in a month requires a written reprimand). Under these conditions, the attributional process may not be active.

Some Empirical Results Supporting the Model

We have conducted a few studies over the last few years that were designed to test a number of propositions of the model. While a detailed description and review of this research is available elsewhere,[2] a short summary of what we have done should be helpful.

So far, we have been able to demonstrate that: (1) Workers do attribute success to internal factors and failure to external factors. (2) That distinctiveness, consistency and consenses affect attributions in the manner predicted. (3) That internal attributions result in more personal and punitive responses directed at the subordinate. (4) That negative or severe outcomes increase the chances that negative responses will be directed at the subordinate.

There are a number of implications of this type of model for both theory and practice. But perhaps the most important point to recognize is that the supervisor is an active processor of information and that a whole variety of both relevant (e.g., past performance) and non-relevant (e.g., similarity) cues affect his or her judgment about a subordinate. A better understanding of this process and its inherent biases should lead to a training program to increases the effectiveness of such supervisor judgments.

FOOTNOTES

1. Wheeler, H. N. Punishment theory and industrial discipline. Industrial Relations, 1976, May, 235-243.

2. Green, S. G. and Mitchell, T. R. Attributional processes of leaders in leader-member interactions. Organizational Behavior and Human Performance, 1979, 23, 429-458.

ISSUES AND TRENDS

Paul A. Gade

Four of the papers selected for presentation at this colloquium were concerned with issues so timely for the needs of the Army that a special session entitled "Issues and Trends" was established for their presentation. These papers dealt with topics that are of interest not only to Army managers and leaders but to civilian managers and organizations as well.

Colonel Walter Adkins' paper presents a somewhat traditional approach to measuring innovation in organizations that is applied to the unique characteristics of the military research organizations. Walter is using this research as part of his dissertation.

In contrast to the more traditional approach used by Colonel Adkins, Dr. Davis' paper suggests that we ought to consider measuring innovation in organizations in new ways. Bob's paper represents a small portion of his soon to be completed book entitled "Organization Innovation and Renewal."

Dr. Fiedler's paper suggests new concepts about managerial effectiveness and new methods for improving the ability of managers to use their cognitive resources. Fred's paper is another in a continuing series of papers and articles in which he has contributed to our theoretical and empirical knowledge about what variables are important to leadership and management in organizations.

Dr. Moskos views the U.S. Army as an emerging organization which has incorporated attributes of both institutional and occupational organizational models. Charlie's paper contrasts a sociological view of the all-volunteer Army with the economistic paradigm that is traditionally used by researchers.

All the papers presented in this session represent issues that are currently of great concern to the U.S. Army. They also represent theoretical and methodological trends for future avenues of research.

ORGANIZATIONAL TOLERANCE OF INNOVATION:
A COMPARATIVE STUDY OF MILITARY ORGANIZATIONS

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This on-going study addresses the impact of organizational structure on creativity and innovation within research and development organizations in a military environment. The central hypothesis holds that the more monocratic the organization the less tolerance for creativity and innovation. A number of sub-hypotheses are being used to establish relationships between creativity and innovation and structural variables such as centralization, size, and formalization. Indications of the validity of the hypotheses will be developed by a comparison to three types of U.S. Army organizations designed for research and development work. The specific purpose of this effort is to develop knowledge useful for improving the capability for creativity and innovation within military organizations.

The greatest interest shown by scholars in organizational creativity and innovation attest to the significance of the subject, but there is considerable disagreement in the literature as to how the process works or how the organizational environment impacts on the process. There is much agreement that variables such as organizational slack, freedom to fail, job security, centralization, formalization, level of conflict, and level of production orientation impact on innovation, but there is little agreement as to the relative weights which should be assigned to the various factors. Very little of the literature addresses the creativity and innovation problem in organizations which are now, and probably must remain, production oriented and monocratic.

Concepts which were found to be common to much of the literature were used as the foundation of the theory of this study. Modifications to insure fit to the military environment were based on exploratory considerations drawn from military experience. The theoretical statement developed for the study holds that organizations which are production oriented, centralized, and hierarchically controlled make for poor innovation. Further, military organizations, because of their unique mission which forces them to be production oriented to a high degree, will probably continue to be centralized and hierarchically controlled. The large, monocratic organizations in the military establishment must rely on separate non-monocratic sub-units--specifically designed for innovation activities--to increase their tolerance for creativity and innovation. Additionally, a sub-unit designed to encourage creativity and innovation will tend to increase in effectiveness as the administration separation between it and the parent organization increases.

The study design used in gathering and analyzing the empirical data needed to test the theory was built around the fact that organizational levels of creativity and innovation are extremely difficult to measure. In this work, a panel of experts was used to develop three categories of Army sub-units classified according to their relative potential for creativity and innovation. U.S. Army research sub-units which are structured like the three type organizations described by the experts were selected for detailed examination. The supervisors of the selected sub-units were interviewed by the researcher and all action officers were asked to complete a questionnaire. Records and reports of the organization were also examined as a part of the effort to develop a clear picture of the characteristics of the sub-unit. The resulting data is being analyzed to develop three indicators of the weight of each dependent variable in each sub-unit. The first of these is being developed from the perceptions of the action officers as reflected in the responses to the questionnaire. One supporting indicator is being drawn from the interviews of the supervisors, and another from the records and reports. The indicators of all sub-units in a type class are then averaged to arrive at three separate indices (perception of action officers, perceptions of supervisors, and records and reports) for each of the three classes of organizations in the typology. The results of this analysis will allow us to associate the level of creativity and innovation of a type of sub-unit with a level of a characteristic shown by that type organization.

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EFFECTIVE USE OF MANAGERIAL ABILITY AND KNOWLEDGE--BEYOND SELECTION AND TRAINING

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Personnel psychology historically interprets its major mission as the development of tests and measures which predict job performance, as well as to enhance such skills and knowledge by training. However, the field has yet to address the equally important problem of identifying the working conditions which enable individuals to utilize these "cognitive resources." This issue is here discussed in the context of military leadership.

Selection and training methods basically assume that individuals use the abilities and knowledge they bring to the job. Hence, the more task-relevant ability, skills, and knowledge they have, the better we expect them to perform. However, the predictive validities of most ability tests have been very low. A review by Schmidt, Hunter, and Pearlman (1980), based on 1917 studies of 226,866 employees, reports median validities of .19 to .26. Likewise, median correlations between leader intelligence and performance have been between .22 and .28 (Stodgill, 1974). Other measures fare even worse. Thus, 13 studies correlating leadership performance with years of leadership experience yielded a median of .12 (Fiedler, 1970). This finding is all the more astounding when we consider that nearly every employment application asks about previous work experience.

One reason for these low correlations of performance with abilities and experience might well be that people cannot always use what is in their heads. Who has not, on occasion, had a job in which he could not function at his usual level, or been in a situation which supported Shakespeare's dictum, "Where ignorance is bliss, 'tis folly to be wise?" What, then, are some of the specific conditions which affect an individual's use of his intelligence and of the knowledge which experience or training provide?

Interpersonal stress is clearly one important factor affecting the utilization of these cognitive resources. Stress generally narrows the individual's intellectual focus, increases rigidity in thinking, and reduces the creativity (e.g., Lazarus, 1966). We also know from studies of social facilitation (Zajonc, 1965; Berkum, 1964) that the stress of being critically evaluated tends to increase performance on simple and overlearned tasks, but reduces performance on newly-learned and complex tasks. Since experience generally enables an individual to develop and overlearn routine solutions, we would expect that experience improves performance under stressful conditions, while intelligence improves performance under conditions of low interpersonal stress. Such other factors as leadership style and task structure also affect the use of abilities and experience. This paper focuses primarily on the effects of interpersonal stress.

A number of our studies throw new light on the conditions under which military leaders use their intelligence and experience. The first study of a recent series (Fiedler and Leister, 1977) was based on 158 infantry squad leaders. Further studies have been on 130 Coast Guard officers, petty officers, and civilian employees in responsible staff positions (Potter and Fiedler, 1980), and on 45 company commanders and staff officers from 9 Army battalions (Fiedler, Potter, Zais, and Knowlton, 1979). Intelligence was measured with the Army's GTS or the Wonderlic Scale (1977); experience was defined as time in military service; and the measure of stress consisted of a scale on which the leader or staff officer rated the stress in his relationship with his immediate boss (SB). Performance was evaluated by superior officers. (Contrary to expectation, a subordinate's rating of stress with his boss is not correlated with his boss' rating of the subordinate's performance.)

We divided each of these samples on the basis of stress with boss ratings, and then correlated intelligence and performance, and experience and performance, for individuals with low, moderate, and high SB ratings. The results showed that leaders used their intelligence but not their experience when SB was low, and used their experience but not their intelligence when SB was high. ("Use" of intelligence or experience is inferred from a positive correlation between performance and IQ or experience.) Even more importantly, perhaps, Coast Guard staff as well as battalion staff officers misused their intelligence under high SB: that is, intelligence correlated negatively with performance under these conditions.

A replication by Borden (1980), based on 438 officers and NCOs of 9 infantry battalions, yielded identical findings on leaders. However, staff officer intelligence was uncorrelated, rather than negatively correlated, with performance under high SB.

That stress inhibits the use of intelligence and creativity was shown by an earlier laboratory study of ROTC teams which were randomly assigned to experimentally induced stress conditions. This study indicated the the leader's creativity scores correlated positively with the group's performance under low stress, but negatively in the high stress condition (Meuwese and Fiedler, 1964). Taken together, our research strongly suggests that the leader's use of cognitive resources depends in large measure on organizational factors rather than his own job motivation. The performance of managerial personnel--and perhaps also non-managerial personnel--should, therefore, be substantially improved by developing conditions which facilitate rather than inhibit the utilization of task-relevant intellectual abilities and knowledge.

Several possible methods for promoting the more effective utilization of cognitive resources suggest themselves. Reducing the vulnerability of key individuals to interpersonal stress by appropriate stress management training may be one way. Individuals in higher management positions could also be trained to relate in a way which is more conducive to the fuller use of their subordinate's abilities and knowledge, or to assign them to tasks in which they can use their abilities more effectively.

Most promising, perhaps, is training which teaches the leader to match his own leadership situation to his leadership style. This approach, called LEADER MATCH (Fiedler, Chemers, and Mahar, 1976), has now been successfully tested in civilian, as well as military, settings. Validation studies have included experienced and inexperienced officers, cadets, and NCOs at various levels (Fiedler and Mahar, 1979). Research indicates that leaders can quickly learn to make changes in their leadership situation, which result in the more effective use of the leader's abilities and knowledge.

Organizational psychologists clearly need to think beyond selection and training. The major challenge which now faces us is the effective use of the brain power an organization is able to attract.

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SOCIAL AND PSYCHOLOGICAL VARIABLES IN ORGANIZATIONAL INNOVATION

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Individuals and organizations do not always adopt innovations when it is in their best interest to do so, and they sometimes perversely abandon successful innovations. This presentation examines some of the variables that have been suggested to account for these paradoxical observations. The focus is on organizational innovations, but the remarks are generalizable to the case of individuals.

The term innovation has been used in different ways, resulting in two quite different research perspectives: (1) regression analyses of innovative products and organizational characteristics; and (2) case studies of the process of innovation. Sociologists, economists, and political scientists have devoted a great deal of energy to the first of these two approaches. Using multiple regression analyses, they have attempted to relate many different organization characteristics, such as size, differentiation, decentralization, slack resources, etc. to innovativeness of organizations. The effort is analogous to the work of trait theorists in psychology who use similar methods, in an effort to relate various traits (behavior classifications) to one another and to other behaviors. Recently, a number of investigators, notably Downs and Mohr (1971), have expressed the opinion that the results of these studies are too inconsistent to allow valid generalizations and some have urged that we shift to a more process oriented approach (Yin, 1978). Numerous factors have been identified that might account for such inconsistencies, most of which are methodological and conceptual.

The second approach is to focus on process, which means looking at innovations within organizations over time. In contrast to the approach described above, this one involves the observation of critical behaviors and incidents in organizations as they conceive of new ways of behaving or new products, techniques, etc.; consider them, tailor them to meet their special needs; adopt, implement, and use them. While it is theoretically feasible to observe such behaviors without the benefit of some organizing framework, the behaviors and incidents will not be bounded in space and time, and hence, will be difficult to observe systematically. There will always be an element of unpredictability about the timing of decisions in organizations and of other events which means that a pure ethnographic approach would be quite expensive and perhaps not very productive. The more commonly recommended case study approach has similar disadvantages, in that it is also expensive and generalization is difficult. What I propose to do here is describe a model for observing process in organizations that enables one to collect systematic data about behaviors and incidents that affect innovation.

The model which I will describe assumes that each innovation application is specific to both the organization in which it is to be implemented and to the type of innovation involved. Specifically, I assume that the success or failure of a given innovation depends upon whether or not certain salient behaviors or incidents occur within a particular setting at appropriate stages in the innovation process. In other words, to predict success or failure of an innovation, we need to know whether certain behaviors did or did not occur.

The model, which I am proposing, postulates that there are four factors which differentially affect four stages in the innovation process, and these in turn determine the success or failure of an innovation, including its durability, which is one of the most important measures of success. The four factors are: (1) innovator motivation; (2) innovator activities; (3) innovation characteristics; and (4) organizational support.

Next, I assume that the process of innovation unfolds in stages, of which there are four: (1) consideration; (2) tailoring; (3) implementation; and (4) continuation. For an innovation to be adopted, each of these four stages must be negotiated or completed successfully. The four factors described above contribute to the success or failure of the innovation at each of these stages, but they contribute differentially.

The model may be visualized as a flow path diagram. The basic data are provided by behaviors and incidents, which may be obtained by direct observation or by questionnaire; these behaviors and incidents are the only exogenous variables in the model. The behaviors and incidents may not be equally weighted and may contribute differentially to the factors. Furthermore, the factors may not be equally salient at different stages in the process. Thus, organizational support may not be very important in the early stages, when a potential innovator is merely considering an innovation for the first time, but may be extremely important when he or she attempts to implement it. Clearly, this model can be stated in the form of a relatively simple equation which weights and sums the behaviors/incidents to obtain a factor score, then weights the factors for importance at different stages and sums them to obtain a single score that predicts success or failure of an innovation.

We have conducted one study at Michigan State in an effort to validate this model of the innovation process. This study is now being prepared for publication. The study looked at a specific class of innovation, audio-visual independent study carrels, used by various faculty in the university. After computing a prediction of success, we then correlated this with the faculty's assessment of overall success to student learning, attitudes, etc. The correlations are, in general, highly significant between success scores using the model and those computed for these other criteria, but some of the sophistications in the model did not signficantly enhance our ability to predict over a simple knowledge of whether or not faculty engaged in the critical behaviors identified.

I have suggested that four sets of factors may account for success or failure. Beyond noting that associated with each of these factors, there are assumed to be unique behaviors and incidents, I have said nothing about how these factors operate. Actually much of the literature from psychology converge on this problem. Thus, with respect to the factor innovator motivation, numerous issues arise: cognitive dissonance, expectancies, risk taking behavior, etc.

Both of the approaches described in this paper are potentially important. Knowledge about how organizational (structural) variables affect innovation would be useful particularly for policy formulation and design of organizations. But we must also look within organizations at specific decisions and behaviors because a knowledge of process may enable us to influence adoption and diffusion in organizations in cases where it is impractical to restructure them.

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CONCEPTS AND METHODS IN THE STUDY OF THE ALL-VOLUNTEER ARMY

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Institutional and Occupational Models of the All-Volunteer Army

My earlier research advanced the hypothesis that the American Army was moving away from an institutional format to one more and more resembling that of an occupation. To describe the armed forces as either an institution or an occupation is, of course, to do an injustice to reality. Both elements have and always will be present in the military system. There was also a recognition that countervailing forces were always in effect. But the concern was to grasp the whole, to place the salient fact.

This is all to say that the institution/occupation dichotomy can serve as a framework, a sensitizing hypothesis, by which the researcher could order data. The essential differences between the two models can be summarized in Table 1.

TABLE 1

Comparison of Institutional and Occupational Models of the Army

Variable	Institutional Model	Occupational Model
Legitimacy	public service; values--duty, honor, country	marketplace economy; individual self-interest
Role Characteristics	total commitment to organization	segmental commitment to organization
Compensation	much in non-cash form or deferred entitlements; pay partly determined by need	salary system; cash-work nexus; pay directly related to skill level
Residence	adjacency of work and residence locales	separation of work and residence locales
Legal Jurisdiction	broad purview over military member	narrow purview over military member
Spouse	integral part of military community	removed from military community
Societal Regard	esteem based on notion of sacrifice	prestige based upon level of compensation

The end of conscription and the perceived "erosion of benefits" symbolized for many a shift in the organizational basis of the military. My present understanding of the institution/occupation model is undergoing reformulation, however. It is problematic whether the volunteer concept per se is intrinsically linked to an occupational orientation. It would be more productive to discern and examine the ways in which institutional and occupational modes coexist and intermesh within the armed forces. My present conception is that there is an emergent form of organization heterogeneity and structural differentiation within the military system. In turn, delineation of institutional and occupational modes are to be related to military efficiency, recruitment and retention, social composition, and the armed forces in the larger societal context.

Research Strategies

A distinction in basic research is that between deductive and inductive research. In somewhat overstated terms, deductive research entails formally stated hypotheses from which appropriate measures and instruments are derived; inductive research develops hypotheses from empirically based observations. Both styles of research are necessary for a cumulative science.

Beyond issues of research premises, there are also questions of methodology. The array of methods available to the social researcher are legion. Yet in most instances of social research, one method is selected to the exclusion of other alternatives. This state of affairs has long characterized the hoary debate between "hard" and "soft" methodologists. But rather than viewing the opposing positions as irreconcilable, advanced methodologists now argue for the utility of a multi-method approach in social research. Such a position seems especially suitable for research on the All-Volunteer Army. A multi-method approach can best identify the interrelationships between societal trends, organizational factors, small-group processes, and individual behavior.

My research intends to be both deductive and inductive as well as multi-method. The institution/occupation formulation by directing attention to data categories illustrates the deductive approach. At the same time, my research employs the inductive style. Thus, for example, my ARI-sponsored research was the first to uncover: (1) among non-prior service (NPS) male accessions, black educational attainment exceeds that of white entrants since the end of the draft (this finding ran counter to virtually all thinking on the social composition of the All-Volunteer Army); (2) the marital composition of junior enlisted personnel has increased significantly under the all-volunteer format (this was an unanticipated outcome of the all-volunteer force). More recently, my field observations point to an overlooked disjuncture in military and civilian comparisons of the movement of women into "non-traditional tasks" (itself a term needing clarification). Unlike most civilian pursuits, military women do not receive higher compensation for performing non-traditional tasks.

A capsule listing of the data collection methods to be employed in the intended research includes: (1) analysis of longitudinal survey data of military personnel; (2) non-survey statistical data, e.g., social background of service personnel, census information; (3) participant observations in military units in various locales; and (4) comparative materials derived from the Navy, Air Force, Marine Corps, military systems in other NATO countries, and non-military organizations.

Contrasting Paradigms of the All-Volunteer Force

Two opposing paradigms of the AVF present themselves. One is based on an economistic premise. It justifies military manpower policies according to civilian-oriented economic criteria, the labor force marketplace, equity, "comparability" with private sector employees, and efficient use of available resources. The other paradigm emphasizes the unique sociological qualities and "service" aspects of the military organization. It is concerned with the social chemistry of unit cohesion, obtaining the analogue of the peacetime draftee in the all-volunteer context, institutional supports for the career force, and citizenship implications of an AVF in a democratic society.

The economistic paradigm has been dominant in Defense Department analyses and supported by generous research funds. The sociological paradigm has been articulated by a small number of academics with meager research support. My own research can be viewed as operating from a framework quite different from that of the prevailing economistic paradigm.

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COLONEL WALTER R. ADKINS (Organizational Tolerance of Innovation: A Comparative Study of Military Organizations), United States Army, Retired, is a native of Alabama who was commissioned in the Infantry upon graduation from the United States Military Academy. He served in that branch, mostly as a parachutist, until placed on the retired list with over 30 years service in 1975. He was assigned for some seven years to various research and development type organizations to include his last tour before retirement as Chief of Staff of the Combined Arms Combat Development Activity at Fort Leavenworth, Kansas. He is a Combat Infantryman, a Master Parachutist, and a Special Forces Officer. Colonel Adkins holds a B.S. in Engineering from the Military Academy, an M.A. in Political Science from the University of Alabama, and he is now a doctoral candidate in Political Science at the University of Alabama.

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G. GAGE KINGSBURY (Computerized Adaptive Achievement and Ability Testing), is a senior staff member of the Computerized Adaptive Testing (CAT) Research Laboratory in the Psychometric Methods Program, Department of Psychology, University of Minnesota. Since receiving his B.A. from Ohio State University in 1974, Mr. Kingsbury has been an active CAT researcher specializing in the applications of CAT to achievement testing. Mr. Kingsbury is working on his Ph.D. dissertation in the area of Adaptive Self-Referenced Testing.

MELVIN H. MARX (Analysis of Reward Functions in Learning), was born on June 8, 1919, in Brooklyn, New York. He was educated in the St. Louis Public School System, and received his A.B. (1940), M.A. (1941), and Ph.D. (1943) in Experimental Psychology with a minor in Zoology from Washington University in St. Louis, MO. He started teaching at the University of Missouri -Columbia in 1944 as an Instructor. Since then, he has been promoted through the ranks of Assistant Professor, Associate Professor, Professor, and is now Research Professor at the University of Missouri - Columbia. Dr. Marx is also the recipient of the NIMH Research Career Award from June 1964 to the present.

THOMAS W. MILBURN (A Study of Leader Behavior in the Effective Management of Organizational Crises), received his B.A. degree in Psychology from Stanford University in 1951, where he also received his M.A. (1955) and Ph.D. (1959) degrees. He worked at the U.S. Naval Ordnance Test Station in China Lake, California from 1957 through 1965, first in Personnel, directing employee development. Later, he initiated and directed an inter-university, inter-disciplinary research effort that became known as Project Michelson which was concerned with the study, within a theoretical framework, of aspects of influence processes relevant as a strategic follow-on to the Polaris system. He taught Psychology and Political Science at Northwestern University and Psychology at De Paul University between 1965 and 1971. Since 1971, he has been Professor of Psychology and Public Policy at Ohio State University. His primary research interests concern conflict, stress, and leadership. During the past few years, he has been using measures of social episodes to approach problems in the areas of substantive interest to him. He and a younger colleague, Kenneth Watman, have just completed the manuscript of a monograph entitled The Nature of Threat: A Psychological Analysis.

TERENCE R. MITCHELL (Decisions about Causes of Poor Performance), Professor of Management and Organization, and Psychology. Advanced Diploma in Public Administration, University of Exeter; M.A. and Ph.D., University of Illinois (Social Psychology). Professor Mitchell's interests are in the areas of organizational behavior, leadership and motivation. He has recently pubished articles on these topics in Organizational Behavior and Human Performance, The Academy of Management Review, The Journal of the Academy of Management, and the Journal of Applied Psychology. He is the author of People in Organizations, McGraw-Hill, 1978, and a joint author of Scott and Mitchell, Organization Theory: A Structural and Behavioral Analysis, Irwin-Dorsey, 1976. In the current year, he will be working on research projects studying leadership and subordinate motivation in several organizational settings. The focus of this research is how supervisors can accurately assess the causes of poor performance of their subordinates and provide appropriate feedback.

CHARLES C. MOSKOS, Jr. (Concepts and Methods in the Study of the All-Volunteer Army), is Professor of Sociology at Northwestern University. He received his B.A. (1956) from Princeton University, and Ph.D. (1963) from the University of California, Los Angeles. He served as a draftee in the Army combat engineers from 1956 to 1958. His publications include: The American Enlisted Man (Basic Books, 1970); Public Opinion and the Military Establishment (Sage, 1971); Peace Soldiers: The Sociology of a United Nations Military Force (University of Chicago, 1976); "The Military", in Annual Review of Sociology, Vol 2 (1976); "The Enlisted Ranks in the All-Volunteer Army," in John Keeley, ed., The All-Volunteer Force and American Society (University of Virginia Press, 1978); and "The All-Volunteer Force," Wilson Quarterly (spring, 1979). He was a Fellow at the Woodrow Wilson International Center for Scholars for the academic year 1980-81.

DARREN NEWTSON (Perceptual Organization of Behavior), is currently Associate Professor of Psychology at the University of Virginia. He received his bachelor's degree in 1967 at Stanford University with distinction and with honors in psychology. He received the first annual dissertation prize from the Society for Experimental Social Psychology for his dissertation entitled "Attribution and the Unit of Perception of Ongoing Behavior." He received his Ph.D. from the University of Wisconsin in 1971. Since that time, he has pursued the problem of behavior perception, using techniques he originated in the dissertation. More than forty studies of the phenomena have been completed under funding from NIMH, NSF, and ARI. A book on the research is in preparation.

JOSEPH M. NOTTERMAN (Individual Differences in Visual-Motor Organization), is Professor of Psychology (past Departmental Chairman) at Princeton University, where he has been since 1956. He received his Ph.D. at Columbia University in 1950. His main research interest has been to establish the constraints under which external and internal, static and dynamic signals combine to govern behavior. Experimental areas to which this interest has extended include: classical (heart rate) and operant (force of response) conditioning, perception of time-variant stimuli, tracking systems, and the perceptual basis of visual-motor organization. His major monographs or books include: Evaluation of Mathematically Equivalent Tracking Systems (with D.E. Page), Dynamics of Response (with D.R. Mintz), and Behavior: A Systematic Approach. He is editor of Experimental Psychology, International Encyclopedia of Neurology, Psychiatry, Psychoanalysis, and Psychology, and is on the Editorial Board, Journal of General Psychology. He served 5-years on the Experimental Research Review Committee, HEW. Dr. Notterman is a Fellow of the APA, AAAS, and the New York Academy of Sciences; he is a Scientific Associate of the American Academy of Psychoanalysis.

JESSE ORLANSKY (Research and Development on Training and Personnel in the Department of Defense). Dr. Orlansky is a member of the staff of the Institute for Defense Analyses.

JAMES SHANTEAU (Training Expert Decision Makers to Ignore Nondiagnostic Information), received his Ph.D. in 1970 from the University of California, San Diego, for his research with Norman Anderson on human judgment. He then spent a postdoctoral year at the University of Mi higan studying decision analysis with Clyde Coombs and Ward Edwards. His research at both the predoctoral and postdoctoral levels was supported by NIMH fellowships. Since 1971, he has served on the faculty at Kansas State University where he was recently appointed Professor of Psychology. During 1979-1980, he was on sabbatical leave as a visiting Research Associate at the Institute of Behavioral Science of the University of Colorado. For 1980, he had been designated as a MASUA Honor Lecturer representing Kansas State University. Since receiving his Ph.D., Professor Shanteau has published 50 papers and chapters, given over 30 invited addresses, and presented 30 papers at conferences and conventions. He has served on the editorial boards of three journals and is a frequent reviewer/consultant for research on decision making. He has been the recipient of nine extramural research grants and fellowships, and seven intramural grants. Currently, his primary research interest is in the application of human judgment and decision making techniques to the analysis and training of experts. His secondary interests include the study of problem solving behavior and the development of quantitative methods in behavioral research.

CLAIRE ELLEN WEINSTEIN (Cognitive Learning Strategies and Study Skills to Improve Retention), was born in Brooklyn, New York, on November 8, 1946. She attended Brooklyn College and graduated with a major in Biology in 1967. During 1967-68 she studied Biology at the Duke University Marine Station, and Southern Illinois University. She spent the following year as a systems developer for the International Business Machines Corporation. She obtained her Ph.D. in Human Learning and Cognition in 1975 from the University of Texas at Austin. Currently, she is an Assistant Professor in the Department of Educational Psychology and Director of the Cognitive Learning Strategies Project at the University of Texas at Austin. She has authored a number of publications in the area of human learning and cognition.

DAVID J. WEISS (Computerized Adaptive Achievement and Ability Testing), is Director of the Computerized Adaptive Testing (CAT) Laboratory at the University of Minnesota and Professor of Psychology. Dr. Weiss received his B.A. from the University of Pennsylvania in 1959, and his Ph.D. from the University of Minnesota in 1963. He has been active in CAT research since 1972. In addition to publishing over 42 technical reports on CAT, as well as numerous journal articles and editing the 1977 and 1979 CAT conference proceedings, Dr. Weiss is editor of the journal Applied Psychological Measurement.

DELOS D. WICKENS (Investigation of Cognitive Control Processes in Conditioning), received his undergraduate degree from Centre College of Kentucky, and both graduate degrees from the University of North Carolina--an M.A. in English in 1933, and the Ph.D. in Psychology in 1937. Since then, Dr. Wickens has taught in the Psychology Department of Ohio State University, the University of Colorado, Oberlin College, and the University of Wisconsin. During World War II, Dr. Wickens was a Senior Analyst investigating gunnery problems in the Navy for the Office of Scientific Research and Development. Dr. Wickens' research interests are in Experimental Psychology, specifically in learning and memory. He uses paradigms of classical conditioning, of verbal behavior, and of animal learning. Wickens has served as the Principal Investigator for a number of research grants and contracts. He has also been selected to serve on the panels of major granting agencies: NIMH panel on Experimental Psychology; National Science Foundation Panel on Psychobiology; Panel on Psychology program, Pioneering Research Unit, Army Quartermaster's Corps; Committee to Study the Status of Human Engineering in the U.S. Army; Research and Development Board, U.S. Government. Professor Wickens has been an Associate Editor of the Journal of Experimental Psychology, 1966-73. He has been President of Division 1 and of Division 3 of the American Psychological Association, Chairman of the Board of Governors of the Psychonomic Society, Vice-President AAAS (Chairman, Psychology Section); Chairman, Society of Experimental Psychologists; President, Midwestern Psychological Association. Recent honors have included: The American Psychological Foundation's Distinguished Teaching Award, 1979; the University of North Carolina Distinguished Alumnus Award, 1979; the Distinguished Research Award of Ohio State University, 1980; the Warren Medal for Outstanding Research, of the Society of Experimental Psychologists, 1973.