

ARI Research Note 2004-01

**U. S. ARMY RESEARCH INSTITUTE  
PROGRAM IN BASIC RESEARCH  
2002 - 2003**

**Basic Research Office  
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**November 2003**



**United States Army Research Institute  
for the Behavioral and Social Sciences**

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**20031121 024**

**U.S. Army Research Institute  
for the Behavioral and Social Sciences**

**A Directorate of the U.S. Army Human Resources Command**

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**REPORT DOCUMENTATION PAGE**

1. REPORT DATE (dd-mm-yy) November 2003		2. REPORT TYPE Final		3. DATES COVERED (from. . . to)	
4. TITLE AND SUBTITLE U.S. Army Research Institute Program in Basic Research 2002 - 2003				5a. CONTRACT OR GRANT NUMBER	
				5b. PROGRAM ELEMENT NUMBER 61102	
6. AUTHOR(S)  Basic Research Office				5c. PROJECT NUMBER B74F	
				5d. TASK NUMBER	
				5e. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) U.S. Army Research Institute for the Behavioral and Social Sciences ATTN: AHRC-ARI-BR 5001 Eisenhower Avenue Alexandria, VA 22333-5600				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) U.S. Army Research Institute for the Behavioral and Social Sciences 5001 Eisenhower Avenue Alexandria, VA 22333-5600				10. MONITOR ACRONYM ARI	
				11. MONITOR REPORT NUMBER Research Note 2004-01	
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution is unlimited .					
13. SUPPLEMENTARY NOTES					
14. ABSTRACT ( <i>Maximum 200 words</i> ): This document contains detailed summaries for each of the U.S. Army Research Institute's basic research contracts for the fiscal years 1998 - 2003. These summaries are grouped according to three Basic Research Office program objectives: Providing fundamental knowledge to improve training in complex, digital environments; providing fundamental knowledge to improve leader assessment and accelerate leader development; and providing fundamental knowledge for identifying and measuring the attributes and skills that are critical to soldier recruiting, performance, and retention in the transforming Army. In addition to summarizing what was done or is being done, each summary also describes the contributions of that research effort to basic behavioral science and suggests how the findings might benefit the Army and other military services.					
15. SUBJECT TERMS					
SECURITY CLASSIFICATION OF			19. LIMITATION OF ABSTRACT Unlimited	20. NUMBER OF PAGES 83	21. RESPONSIBLE PERSON (Name and Telephone Number) Paul A. Gade 703/617-8866
16. REPORT Unclassified	17. ABSTRACT Unclassified	18. THIS PAGE Unclassified			



## **FOREWORD**

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The purpose of this document is to communicate the annual progress for each individual research project in the Basic Research Office (BRO) research program at the United States Army Research Institute for the Behavioral and Social Sciences (ARI). The summaries contained herein are written by the scientists who are performing the work to provide a snapshot of their continuing efforts. In addition, BRO conducts a more detailed in-progress review of each project each year. If successful, the projects within BRO's basic research program will lay the foundations for many of ARI's future applied behavioral research efforts.



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## **THE BASIC RESEARCH PROGRAM: IDENTIFYING NEW AND PROMISING TECHNOLOGIES**

The Basic Research Office (BRO) research program focuses on providing the the basic research underpinnings for the personnel, leader development, and training requirements of the future. This program is a critical link between the world of behavioral science and the military community. Searching out and advancing the state-of-the-art methods, theories and findings in behavioral science, encouraging projects most likely to contribute generalizable scientific principles and new knowledge, and supporting those efforts that have potential military relevance and likelihood of leading to applied behavioral technology are BRO's key research goals.

Universities conduct most of the basic research program. BRO maintains close contact with other basic behavioral science research organizations as well as with ARI's applied researchers and other relevant agencies within the Army and other military services. These contacts help to define issues that require fundamental research, and facilitate the transition of basic research results to applied programs for eventual use by the operational Army.

In BRO's contract programs, a Broad Agency Announcement (BAA) is issued each year to solicit both concept papers and formal proposals relating to the announced program research areas. In a given year, the BAA highlights the research objectives of special interest, and provides an open call for proposals.

On the following pages, the reader will find summaries of current, on-going BRO contracts ranging over the period 1998 - 2003. There are three current BRO program objectives, each of which will be discussed in detail below. They are as follows:

1. Provide fundamental knowledge to improve training in complex, digital environments,
2. Provide fundamental knowledge to improve leader assessment and accelerate leader development,
3. Provide fundamental knowledge for identifying and measuring the attributes and skills that are critical to soldier recruiting, performance, and retention in the transforming Army.

### *Training for Speed in Knowledge*

Basic research in this area focuses on developing concepts and methods for training complex tasks and for sustaining complex task performance. Assessing the cognitive impact of technology requirements arising from digital systems, semi-automated systems, and robotic systems, on training requirements is also part of this process. One of the efforts in this area seeks to understand the impact of the voluminous multi-modal data on performance and how individuals and teams might be trained to integrate and use such rapidly presented data. We seek to identify unique training principles and methods for improving interpersonal skills and team adaptability and performance. The expected outcome is applied research testing the principles and methods produced in this work package in Army training environments. The models and theories produced should be useful in accounting for individual differences in training and facilitating practical, individualized, adaptive training methods. These advances will translate into improved training methods in a wide range of tasks.

### Assessing and Improving Leader Skills

Commensurate with the requirements for rapidly developing adaptable, flexible leaders, the basic research program in leader development is directed toward providing concepts and methods for accelerating leader development and understanding and developing leader adaptability and flexibility in a manner that can be tested in the applied environment. One of our major efforts in this area uses Sternberg's theory of practical intelligence to develop new techniques for acquiring experience-based, tacit knowledge as a means for rapidly developing effective military leaders. We are also committed to discovering and testing the basic cognitive principles that underlie effective leader-team performance. Understanding the dynamics of small group leadership in face-to-face and distributed team environments is a key aspect current basic research program in leadership. For example, one of our research projects seeks to develop leadership techniques that foster interaction, communication, and trust in electronic environments. Another examines the development of team leadership behaviors under the stress of performing in a metropolitan hospital shock trauma center and in the laboratory. We are completing an investigation of how turnover hinders or helps team performance. Although turnover can be harmful, for example, when a team loses a productive member and must expend time and energy training a replacement; turnover can also be helpful, as when a team loses an unproductive member and gains a replacement with valuable knowledge. We anticipate that results from this research will make an important contribution to understanding and improving organizational effectiveness.

### Personnel Issues for the New Century

Identifying and measuring the aptitudes and skills that are unique to the human performance requirements of military service is a major theme of this basic research effort. As part of this process, we seek to devise methods that assess mental flexibility and adaptability, describe how these attributes develop, and measure their contribution to performance and job tenure. For example, we have begun a new effort to assess individual mental flexibility since mental flexibility plays a critical role in the successful application of the mental processes needed for adapting to, selecting, and shaping the environment in novel situations. Exploring the sociological and psychological factors that could influence recruitment, retention, and performance is part of this work package as well. Applied research that builds the understanding of the cognitive processes entailed in flexible thinking can be used to identify those who are flexible, adaptable thinkers and to develop effective instructional programs that facilitate the use of flexible thinking strategies in a variety of contexts.

This document provides a listing and brief synopsis of ongoing and recently completed research efforts. Project listings are organized into the three aforementioned research objectives. It is important to note, however, that this program is but one of many programs for which BRO has responsibility. Other programs in BRO include:

- Small Business Innovative Research (SBIR) Program,
- Small Business Technology Transfer (STTR) Program,
- International Behavioral Science and Technology Watch,
- Graduate student apprenticeship program - Consortium Research Fellows Program – with the Consortium of Metropolitan Washington Universities,

- Outreach efforts to Historically Black Colleges and Universities (HBCUs) and Minority Institutions (MIs), and
- Research support in behavioral science for the U.S. Military Academy.

Additional information about reports from these research efforts is available upon request.



## **BRO RESEARCH OBJECTIVE #1:**

*Provide fundamental knowledge to improve training in complex, digital environments.*

Research under this objective develops concepts and methods for training complex tasks and sustaining complex task performance. The focus is on understanding the cognitive impact of Future Force technology on training requirements, the impact of voluminous multi-modal data on performance, and developing methods for improving the interpersonal and cognitive skills that affect team performance.



## **Training For Rapid Interpretation of Voluminous Multimodal Data**

**Contract #:** DASW01-02-K-0001

**Contract Dates:** 5/1/02-9/30/04

**Institution:** Georgia Institute of Technology

**PI:** Dennis J. Folds

### **Research Summary**

The overall goal of our research is to increase understanding of how individuals and small teams make decisions when they must process a large amount of information very rapidly. A second goal is to determine how to improve this ability through training. We are studying the effects of data format (photographs, audio files, video clips, text messages, computer graphs, and map-based icons) on rapid decision making. We are also studying the effects of overall information volume (i.e., the total number of information items that a person must process before making a decision) and information density (i.e., the number of information items relevant to the decision). We are identifying the types of errors that people commonly commit when making decisions in this manner, and are studying different ways to improve their performance through training.

We are conducting a series of laboratory experiments with individuals and small teams. The specific objective for each experiment is as follows:

- Experiment 1 – Assess the effects of data format, density, and overall volume on decision making performed by individuals.
- Experiment 2 – Assess effectiveness of anti-bias training for individuals.
- Experiment 3 – Assess the effects of data format, density, and overall volume on decision making performed by small teams.
- Experiment 4 – Assess effectiveness of anti-bias training for small teams.

The participants in our study use a simulation of a hand-held computer that receives information over a data link. The information is in the form of a video clip, a photograph, a text message, and audio file, a computer-generated graph, or an icon on a map. These information items arrive in rapid succession in the 'inbox' and must be reviewed by the participant. They use the information to make decisions about potential incidents (such as a car bomb) that they are supposed to report. The information they receive also contains a lot of false leads that should be rejected. We developed our patterns of false leads so they would tend to produce the types of decision errors found in previous research.

### **Contributions to Basic Research**

The current work advances basic research in the areas of naturalistic decision making, team decision making, and in training to improve decision making. Previous research has identified characteristic errors (sometimes called biases) that humans commit when making decisions based on incomplete or conflicting information. Many of these biases seem to arise from unconscious strategies that reduce the effort required to process information, thereby allowing quick decisions to be made. Our research is examining whether these same types (or perhaps different types) of errors occur when an individual or small team is processing large volumes of information very rapidly. We are also investigating whether the same cognitive processes that produce the biases in the first place could be used to help counter the bias, through

training. Specifically, we are studying whether individuals can learn to recognize the patterns of information that tend to produce errors.

### **Potential Army/Military Applications**

The applications of this research for the Army are related to training individuals and small groups to assess information received in the field and to make rapid decisions based on that information. While in the field, an Army Unit of Action may receive information over a data link and downloaded to a hand-held computer, or through normal voice communications over the radio. Specific techniques that might be trained include spotting the 'markers' of a situation that tends to produce a decision error, and the specific countermeasures to take once the markers are spotted.

### **Accomplishments**

We have completed the first major experiment (Experiment 1) and two small-scale pilot studies. Our first small-scale study helped us refine the information presentation methods and to set the pace of information presentation so that subjects would have just enough time to process all the information and to make rapid decisions. Our second small-scale study helped us develop the division of responsibilities for a three-person team and structure the tasks the team members will perform. Data analysis is still in progress for Experiment 1. Preliminary results show that our participants were able to make correct incident reports for about 50% of the true incidents, and that they were filing reports based on false leads for about 25% of the false leads.

We have also completed much of our preparation for Experiment 2 and are conducting a small-scale pilot study that will help us refine the training techniques to be used in Experiment 2.

### **Future Plans**

During the next year we plan to complete Experiments 2 and 3 and begin work on Experiment 4. Experiment 2 will examine the effectiveness of anti-bias training for individuals. Individuals will be trained to spot the markers of situations that tend to produce errors, and to report that they have spotted those markers. In Experiment 3, we will extend our research to include small teams (teams of three individuals) who are working together to rapidly process information and make decisions. In Experiment 4 we will study training techniques for small teams.

# **Optimizing The Speed, Durability, And Transferability of Training**

**Contract #:** DASW01-99-K-0002  
**Institution:** University of Colorado

**Contract Dates:** 8/1/99-7/31/03  
**PI:** Alice F. Healy  
**Co-PI:** Lyle E. Bourne, Jr.

## **Research Summary**

The U. S. Army spends much time and many resources in training its personnel. Training is essential because recruits cannot be expected to come equipped with the military knowledge and skills they will need in the field. But training is costly, so it is important to insure that it be accomplished as quickly and as efficiently as possible. Increasing training speed, however, should not be the only, or even the most important, consideration. If soldiers have successfully learned how to perform a task during training but then forget how to perform it at the time that they need to do so, the training has clearly been inadequate. Passing a test at the end of training does not guarantee later success in the field. Training needs to be durable as well as efficient. But even durable training cannot guarantee that learned knowledge and skills would be applied successfully to situations different from those encountered during training. Training circumstances can rarely capture the full set of circumstances under which tasks are encountered in the field. It is, therefore, essential that training be transferable as well as durable. It has been the aim of our research program to develop principles that separately optimize the three major aspects of training: (a) speed or efficiency, (b) durability or long-term retention, and (c) transferability or generalizability to new situations.

## **Contributions to Basic Science**

The many research directions we have pursued address a diverse set of issues but have two primary goals. First, we intensively examined extraneous variables (including factual overload, rapid presentation of information, stress, frustration, and fatigue) that might adversely affect training in order to develop procedures to counteract their deleterious effects. Second, building on previous work, which revealed that long-lasting knowledge and skills are highly specific to the training conditions, we conducted a series of studies concerned with optimizing the relationship between all three major aspects of training – its speed, durability, and transferability. These studies share a common analytical and experimental methodological approach and the common theoretical goal of understanding the psychological principles underlying the acquisition, retention, and generalization of knowledge and skills.

## **Potential Army/Military Applications**

These studies also share the common applied goal of improving the training of military personnel. In particular, our research will improve training techniques to enable knowledge and skills to be acquired quickly, yet be still accessible across long delay intervals with no practice and adaptable to new situations outside the training environment. The balance of the three aspects of training (speed, durability, and transferability) is not necessarily fixed across tasks or even within a given task but rather may depend on a variety of external factors, such as stress, frustration, fatigue, speed of information presentation, and information load, that can change from time to time. Variations in any one of these factors can affect the interaction of these

aspects of training. Hence, our studies also examined the three aspects of training under various conditions of stress, frustration, fatigue, speed of information presentation, and information load. This examination should help the military design training programs that will allow the trainee to contend with these external conditions that obtain unpredictably in the field and could adversely influence performance if not properly managed.

### **Accomplishments**

Although many of our studies have overlapping goals, in the present summary we focus on a subset of our studies and discuss two separate topics. The first topic involves managing factual overload, rapidly presented information, stress, frustration, and fatigue, with an emphasis on tasks involving perceptual and motoric processing. The experiments reported for this topic focus on the specific issue of initiating and executing response components under fatigue produced by prolonged work. The second topic involves optimizing the balance of the three major aspects of training. The study reported for this topic focuses on ways to promote transfer of training.

Managing factual overload, rapidly presented information, stress, frustration, and fatigue. When participants work continuously over time on a task, such as data entry, two opposing processes (facilitative and inhibitory) might affect their performance. On the one hand, performance might improve, becoming more accurate, faster, or both, as participants master the skills required of data entry. On the other hand, either or both aspects of performance might deteriorate as participants suffer the effects of fatigue and boredom over long trial periods. We completed two experiments addressing fatigue in a repetitive data entry task. Under conditions promoting fatigue, participants entered four-digit numbers on a computer terminal. In Experiment 1, accuracy worsened but response times improved both across and within session halves, reflecting an increasing speed-accuracy tradeoff. In Experiment 2, the (largely cognitive) time to enter the first digit of each number improved over the first session half but worsened over the second half. Accuracy worsened but time to enter the remaining digits improved across though not within session halves. The (purely motoric) time to press the enter key improved across and within session halves. Thus, through a combination of practice and fatigue, prolonged work affects the component cognitive and motoric processes of data entry differentially and at different points in practice.

An additional experiment investigated effects of articulatory processing on number data entry (i.e., processes involved in saying or subvocalizing the numbers). Participants entered four-digit numbers presented as either words or numerals on a keyboard either under articulatory suppression or in silence. The articulatory suppression group typed initial digits *faster* than the silent group, but for subsequent digits, the opposite pattern occurred at least with word stimuli. Thus, articulation of numbers, which promotes entry into the phonological loop of working memory (i.e., a transient, low-capacity memory store for previously articulated items), retards processing of initial digits but enhances processing of subsequent digits.

Optimizing the balance of training aspects. Our research also examined training, retention, and transfer of a duration estimation skill using an arbitrary unit of time in a prospective, production estimation paradigm. Specifically, subjects produced time intervals on demand, knowing in advance that they would be required to do so. For example, they were asked to indicate by clicking a response key when 32 time units had elapsed since a beep

sounded (with each unit equal to 783 ms). Participants were trained with feedback and then either tested immediately for transfer without feedback or retrained with feedback 1 week later. There were three training and retraining conditions, two involving secondary tasks. Retention of the duration estimation skill was perfect across the 1-week delay when the secondary task condition was unchanged, but there was no transfer of the primary duration estimation skill when the secondary task condition was changed. These findings are interpreted within the procedural reinstatement framework (i.e., a theoretical framework based on the hypothesis that retention and transfer of learned knowledge and skills depends on duplicating the learning procedures at the time of test), with the assumption that the primary duration estimation procedures incorporate requirements of the secondary task.

### **Final Summary**

Our research program aims to develop principles that optimize simultaneously all three characteristics of training – speed, durability, and transferability of learned knowledge and skills. Such simultaneous optimization would not necessarily optimize any one characteristic alone but would require instead a balanced consideration of all three characteristics. The balance of the three aspects of training is not fixed across tasks or even within a given task but rather can depend on a variety of external factors, such as stress, frustration, fatigue, speed of presentation of information, and information load, that can change from time to time. The studies summarized illustrate our completed work on two topics. The experiments reported on the first topic involve a data entry task. They focus on the specific issue of initiating and executing responses under fatigue produced by prolonged work. These experiments demonstrate that prolonged work affects the cognitive and motoric processes of data entry differentially and at different points in time. The experiments reported on the second topic involve a duration estimation task, which is in some cases coupled with a secondary articulatory suppression task. They focus on ways to promote transfer of training. These experiments demonstrate that learning how to estimate durations is highly specific to the conditions of training and critically depends on whether or not a secondary task is required. These studies further support the theoretical framework for understanding training, retention, and transfer of knowledge and skills that we have called “procedural reinstatement.” This framework not only accommodates the results of our extensive series of laboratory studies, but also suggests a set of training principles that can be used to optimize the speed, durability, and transferability of military training. Specifically, for example, the following pair of training principles are suggested: (a) Reinstatement the conditions of study as closely as possible when taking a test or performing in the field. If it is possible to anticipate test or field conditions, then modify training conditions to match them. (b) To be effective, training must incorporate the complete set of field task requirements, including all secondary tasks likely to be represented in the field. Instructors and course planners sometimes assume that teaching a primary task without extraneous requirements will benefit the learning process. However, if such secondary task requirements exist in the field, then use of this training method will not provide optimal transfer to field performance. This effect works both ways. That is, training with extraneous secondary task requirements will not be optimal if field performance does not include those requirements. In general, learning is highly specific to the conditions of training. Thus, for optimal performance, the entire configuration of task requirements during training needs to match those in the field.

## **Training for Efficient, Durable, and Flexible Performance in The Military**

**Contract #:** DASW01-03-K-0002  
**Institution:** University of Colorado

**Contract Dates:** 10/1/02-9/30/06  
**PI:** Alice F. Healy  
**Co-PI:** Lyle E. Bourne, Jr.

### **Research Summary**

The proposed research builds on our earlier studies of skill training, retention of trained skills after a long delay interval, and transfer of trained skills to novel situations. On the basis of that research we were able to develop a set of training principles that individually optimize the efficiency and durability of trained performance. But we have also discovered that conditions that lead to durability often, and perhaps always, lead to limited flexibility or adaptivity. In fact, in our most recent research, we have found that training has little or no benefit if there are discernable differences between the training and testing situations in the background or context, even if there are no changes made in the primary task requirements. The focus of this proposed project is, thus, to develop training procedures for teaching knowledge and skills that will survive primary task or background changes and, thereby, produce flexible, as well as efficient and durable, performance in military tasks. The proposed experiments are divided into three major groups. Experiments in the first group are designed to understand how individuals can be trained to contend with an unpredictable flow of information often large in quantity, rapidly presented, and ambiguous. Experiments in the second group aim to identify training factors that promote adaptive and flexible performance in the field. The final group of experiments examines performance in dynamic and changing task environments. We conclude with an effort to create a complex set of laboratory tasks similar to those encountered by a digitally proficient pilot operating a fully computerized cockpit, and not unlike those of the digitally proficient "land warrior" soldier of tomorrow. The major aim is to determine the extent to which training principles, first established in a simple laboratory task, generalize to performance under these more complicated conditions.

### **Contributions to Basic Science**

We have proposed the following theoretical principles for optimizing training: principle of contextual interference, training difficulty hypothesis, depth of processing principle, procedural reinstatement principle, specificity of training principle, functional task principle, and strategic-use-of-knowledge principle. The primary purpose of our proposed experiments is to collect data that will allow us to accept or reject each of these training principles that we formulated on the basis of our earlier basic laboratory research and to develop and test new principles that are supported by these data.

### **Potential Army/Military Applications**

Our proposed experiments could be used to drive applied research. To illustrate this potential symbiosis between basic and applied research, we give two brief examples: First, our research has demonstrated a high degree of specificity from training to subsequent application. These findings have crucial implications for military training because instructors often assume that teaching a primary task without extraneous secondary task requirements will benefit the

learning process. However, our findings imply that to be effective, training must incorporate as many as possible of the complete set of field task requirements, including all secondary task requirements that might be imposed. In the proposed research, we will test the boundary conditions of our finding using a variety of primary and secondary tasks, and we will test hypotheses concerning ways to overcome this severe specificity. Although the tasks we are using in our research are often components of military tasks and require digital proficiency, they are not the real military tasks currently being trained in the Army. We would hope that applied research units would be interested in testing whether the specificity of training principle we have developed would apply to such real tasks and whether the methods we hope to develop for overcoming this problem could be adapted to improve military training. To that end, we have had discussions with Stephen Goldberg (Chief, Simulator Systems Research Unit) about future collaborative research on the applicability of our training principles to simulator training. Second, military instructors often attempt to use procedures that make learning easier and speed up initial skill acquisition. But our research has shown that introducing sources of interference into a task or increasing the difficulty of the task slows down initial skill acquisition but leads to ultimate improvements in the durability and flexibility of the learned skill. In our proposed research, we will test this principle in a variety of task domains, and we will test an extension of this hypothesis, namely whether the difficulty of a secondary task has a similar inhibiting effect on initial learning and facilitating effect on retention and transfer as does the difficulty of a primary task.

### **Accomplishments**

In the present summary we focus on the accomplishments in two of our series of experiments that have helped us to confirm previously proposed training principles and to identify possible new principles.

The first series of experiments concerns response execution in a motoric coordination task involving various forms of hand-eye incompatibility between computer mouse and monitor cursor. We found that practice with a given form of incompatibility led to large improvements during training and high durability across a 1-week delay but minimal transfer from one type of incompatibility to another. Even when subjects practiced with a mouse that combined up-down and right-left incompatibility, there was no transfer to performance with a mouse that involved only one of the types of incompatibility. Also, training with the more difficult right-left incompatibility did not aid in performance with the simpler up-down incompatibility. The implications for military training is that when eye-hand coordination is involved in a skill, for practice to be effective, the specific forms of hand-eye incompatibility required must be trained in the particular way that will be encountered subsequently in the field.

The second series of experiments concerns types of strategies and strategy transitions during training of a classification skill. We found that both rule difficulty and rule salience determine the strategy that subjects eventually adopt during training. In the present case, where the same simple rule was used in all tasks, the strategy adopted was rule-based or instance-based, depending on the salience of the rule. These findings imply that to optimize performance trainers need to be aware of both the salience and the difficulty of the operative rule for responding in any given task. No matter how simple it is, when a rule is not obvious, learners may adopt a strategy in which they memorize specific instances rather than use the underlying rule.

## **Future Plans**

Our proposal was divided into three substantive sections, with each section further divided into three subsections: (a) dealing with information flow, (b) factors promoting adaptive and flexible performance, and (c) coping with dynamic environments and changing task demands. We gave a detailed description of at least one major experiment in each of these subsections. During the first year of the project, experiments were conducted on each of the three substantive sections; three major experiments were undertaken that year, one in each of the three sections. We are currently analyzing the data from these experiments, and the data analysis should be complete by the end of the first full year of the contract (i.e., September 30, 2003). The specific experiments to be conducted in the following year of the contract will depend in part on the outcome of these data analyses. However, we plan to conduct at least five additional major experiments in the second year of the contract. These five experiments, like the three initial ones, will represent all three sections of the proposal. During Year 2, we also plan to write up and submit for publication one or more manuscripts based on the work completed in the first year of the contract. In addition, we hope to extend our discussions with Dr. Goldberg about possible collaborative applications of our research to military simulator training.

## **FOCUS: A Program for Training Sensemaking Skills**

**Contract #:** 1435-01-01-CT-31161  
**Company:** Klein Associates Inc.

**Contract Dates:** 6/18/01-6/17/04  
**PI:** Gary Klein

### **Research Summary**

The main objectives of this research effort are (a) to develop a model that describes the cognitive process people follow in order make sense of a situation, and (b) to identify training interventions based on this model to improve individuals' sensemaking performance.

### **Contributions to Basic Science**

The sensemaking model developed in this effort describes a higher-order cognitive process that is a critical component of decision-making success in naturalistic environments. Sensemaking drives the ability to comprehend the meaning and relevance of large amounts of ambiguous data. This ability separates the individual who is on top of the situation, and able to form expectancies to guide smooth performance, from the individual who is continually surprised and confused and acts hesitantly in responding to the crisis of the moment. This effort contributes to basic science by describing this critical cognitive process and exploring ways to improve performance of this process through training.

### **Potential Army/Military Applications**

An understanding of sensemaking is relevant to Army efforts to design various types of decision support systems. By describing how humans actually use information to develop and revise interpretations of a situation, we can develop command and control and other technologies that work in concert with the human and support his/her natural process for filtering information and building and maintaining situation awareness. Our findings-to-date on the nature of the sensemaking process offer initial guidance on several important issues in the field of decision support, such as the effect of information rate on skilled performance and possible evaluation metrics for systems intended to bolster sensemaking activities.

Defining the process of sensemaking also appears to be relevant to Army training needs. Our findings illustrate areas in which sensemaking can break down and even fail. Training programs can be structured to enable practice and feedback in key sensemaking activities. Our findings also highlight areas of expert/novice differences. Training scenarios can be structured to deliberately build sensemaking expertise in non-experts through the development of mental models, fragmentary mental models, and anticipatory thinking skills.

### **Accomplishments**

The first two years of this effort have produced several significant findings about the nature of sensemaking. First, we have defined sensemaking as the process of fitting data into a frame, and fitting a frame around the data. People will try to make sense of data inputs they

receive by finding or constructing a story to account for the data. At the same time, their repertoire of stories will affect which data elements they consider and how they will interpret these data. Thus, the frame and the data work in concert to generate an explanation. We also suggest that data elements are not perfect representations of the world, but are constructed. They are sampled from the available information and defined in terms of the available frames. They are abstractions from the environment, and therefore, distortions of reality. We assert that no more than three or four of the key data elements serve as anchors, which elicit the initial frame used to sample for more data elements.

In our Data/Frame model of sensemaking (Klein et al., 2003), we have differentiated and described six activities, or building blocks, of sensemaking: elaborating the frame, questioning the frame, preserving the frame, comparing frames, seeking a frame, and re-framing. Further, we have identified two sensemaking cycles that encompass these activities: the assimilation and accommodation cycles, corresponding to the usage suggested by Piaget (1954). During assimilation, the person fits data and information into the frame or cognitive map. During accommodation, the person alters the frame to fit the data.

We also extended our discussion of quasi-logical reasoning (Klein, Phillips, Battaglia, Wiggins, & Ross, 2002) into the notion of “possibility theory,” as opposed to probability theory and deductive inferences. The reasoning we observed in our incident data rarely employed deductive logic. Instead, it was aimed at employing inferences in order to identify anchors that could be used in sensemaking. We assert that quasi-logical reasoning and possibility theory are strengths in the process of sensemaking.

Consistent with prior research (Barrows, Feightner, Neufeld, & Norman, 1978; Chase & Simon, 1973; Elstein, 1989), our findings also suggest that expert/novice differences in sensemaking performance are not due to superior reasoning and inferencing strategies on the part of the expert, but rather to the quality of the frame that is brought to bear. Experts have more factual knowledge about their domain, they have built up more experiences, and they have more knowledge as to cause and effect relationships. They are more likely to generate an accurate explanation of the situation than novices because their frame enables them to select the right data from the environment, interpret it more accurately, and see more pertinent patterns and connections in the data stream.

Our research also suggests that developing a comprehensive mental model for a complex, open system is unrealistic. Instead most people, and even most experts, rely on fragments of local cause-effect connections, rules of thumb, patterns of cues, and other linkages and relationships between cues and information to guide the sensemaking process (and indeed other high-level cognitive processes). We believe that a set of fragmentary mental models (FMMs) contribute to the frame that is constructed by the sensemaker, therefore guiding the selection and interpretation of data.

We have elaborated the model such that it can be used to generate testable hypotheses—including non-trivial and non-obvious hypotheses—and have presented several hypotheses as starting points for model testing.

## **Future Plans**

In Year Three, we will conduct a series of experiments, including a training approach to boosting sensemaking skills in a particular domain. Our goal will be to test some of the hypotheses we have generated based upon the model.

Specifically, we will (1) examine the effect of the amount of information on sensemaking performance, (2) investigate the differences between Endsley's (1995) model of situation awareness as a state of knowledge, and the Data/Frame model of sensemaking as a process, and (3) explore a training approach using Cognitive Task Analysis data to improve sensemaking through the development of fragmentary mental models.

## **Understanding Aspects of Individual and Collaborative Skill Acquisition in Face-to-Face and Distance Training Situations**

**Contract #:** DASW01-01-K0003  
**Institution:** New Mexico State University

**Contract Date:** 9/1/01-8/31/04  
**PI:** Adrienne Y. Lee  
**Co-PI:** Douglas Gillan &  
Nancy Cooke

### **Research Summary**

The purpose of this research is to examine: a) whether teams training together in the same location (co-located) will train more quickly and efficiently than teams who are not in the same location (distributed); b) whether testing in the same situation/context (co-located to co-located and distributed to distributed) is better than training in different situations/contexts (co-located to distributed and distributed to co-located); c) whether we can develop training to improve the transfer between contexts; and d) whether the training will improve learning.

Originally, the focus was on Unmanned Air Vehicles (UAV) where 3 individuals with different jobs all must fly an UAV to various locations and take pictures of specific targets. The new focus is on peacekeeping missions where 3 individuals manage different resources in a Support and Stability Operations (SASO) task. Both of these contexts are simulated in the laboratory and training/testing is performed using the methodology described below.

### **Contributions to Basic Research**

In recent years, the advancement of military technology has resulted in highly complex skills that need to be acquired and maintained to use that technology (Barry & Runyan, 1995). Consequently, the demand for ongoing innovations including distance training has increased. Distance training has been shown to be extremely cost effective and has produced similar learning outcomes. Although extensive research on distance learning exists, few studies have focused on group (collaborative) distance training delivered by internet/web-based technologies.

A parallel development has occurred in the area of team training. Even though group (collaborative) learning has been the focus of many studies (Slavin, 1996) and progress has been made on knowledge measurement at the individual level, the measurement of team knowledge, and team cognition in general, is still in its infancy (Cooke, Salas, Cannon-Bowers & Stout, 2000). Thus, research on how to improve team distance learning can contribute significantly to the field in several areas including distance education and across context team transfer.

Interest in distance education has increased due to a concerted effort on the part of public educational institutions to reach new populations of students who might not otherwise be able to attend. With advancements in technology, this has been possible (particularly in the use of web-based training). On the other hand, few controlled studies exist to determine what is truly beneficial.

Our controlled team distance training research will also contribute to the transfer literature generally. Research has been performed on individual transfer (Singley & Anderson).

Although specifications for transfer are delineated, research on context effects has not been as conclusive (see McDaniel, Anderson, Einstein & O'Halloran, 1989 or Wickens, 1987). The current research focuses on describing the effects of a particular physical context change on team performance (with a focus on cognitive skills but also some measurement of social skills).

### **Potential Army/Military Applications**

The applications to the military are expected to be in training principles for distance and transfer situations (changing from one situation to another). Specifically, these studies are designed to determine what conditions promote distance training and transfer and what training is needed to improve team and distance transfer. In addition, within the studies, various assessment measures will be used that will focus on individual and team cognitive and social (social-cultural) skill development.

### **Accomplishments**

In the Spring and Fall 2002, the first study on co-located/distance team training and transfer was performed in the UAV CERTT lab. Our results indicated that although all teams received the same initial declarative knowledge training, distance teams outperformed co-located teams throughout the initial hands-on training sessions and after transfer. The distance teams reached a plateau but this was probably due to a lack of feedback. After transfer, all teams experienced a decrement in performance (similar to Singley & Anderson, 1989) but the distance teams (i.e., those who trained at a distance and either stayed in the same distance condition or transferred to a co-located condition) showed a greater improvement for the two training missions after transfer. These results may have been due to the small numbers of teams or the experimental setup in the UAV lab that may have suppressed co-located performance. We are replicating this research in a new stability and support operations (SASO) lab.

### **Current Research and Future Plans**

For Spring and Summer 2003, the focus has been on analyzing the data collected in the UAV CERTT lab and determining which measures are most useful to keep. A summary of the measures used and inclusion information follows. The general anxiety measure worked well but was not specific enough to the task. The trust measure also worked well but never reached high levels. Because these results indicate that developing specific team trust building materials might be useful for the second study, materials used in pilot testing in the Spring 2002 are being adapted for the new lab studies. The first experiment included many knowledge measures, including one that was similar to Pathfinder measures. These measures appeared too diffuse and more specific measures are being developed for the second study. Many other team measures were used in the first study based upon what had been used previously in the CERTT lab. Of these measures, only a few will be used for the second study. No measure of socio-cultural variables was used in the first study; however, for the second study, the context (SASO) invites a look at cross-cultural beliefs and therefore some cross cultural measures will be added. In the first study, the bulk of the questionnaires came at the end of the experiment (although the knowledge assessments were distributed). In the second experiment, these questionnaires will be distributed throughout the experiment.

The main focus in the late spring and early summer has been on the building of the lab and testing of software. The current full implementation of the software is well understood and we are requesting changes from Aptima in order to run the second study. In addition, tutoring systems are being developed to provide initial information and team training before the SASO missions are run (using the software). The lab should be ready for the experiment by the end of August.

# **Exploring the Interaction of Implicit and Explicit Processes to Facilitate Individual Skill Learning**

**Contract #:** DASW01-00-K-0012  
**Institution:** University of Missouri-Columbia

**Contract dates:** 9/00-8/04  
**PI:** Ron Sun  
**Co-PI:** Robert Mathews

## **Research Summary**

Any high level of skill depends on both conceptual and subconceptual (experiential) knowledge. However, experts are often only aware of their explicit conceptual knowledge. Experientially acquired subconceptual knowledge is more akin to pattern recognition. For example, when you recognize a friend's face, you instantly know who the person is, but you may not be aware of what cues or features are being used to recognize him/her. This lack of awareness of essential experiential knowledge creates serious challenges for training and learning in the military as well as civilian context. The purposes of this research program are (1) to experimentally investigate the interaction between knowledge gained from hands-on experiential (implicit) learning and explicitly formulated conceptual knowledge in the development of skills and expertise, (2) to clarify how conscious reflection and resulting conceptual knowledge can be employed to enhance, rather than interfere with, experiential learning, (3) to discover the optimal mix of experiential and conceptual training over a range of skill acquisition from early novice to a high level of expertise, and (4) to develop computational models and theories of human skill learning that emphasize the interaction of these two types of learning, which may be of use in structuring and optimizing training, on the basis of our experimental and simulation results.

## **Contributions to Basic Research**

The current work advances basic research in the areas of learning and cognition. One product of this effort is a comprehensive conceptual framework describing the ways these two types of knowledge interact to produce expertise in tasks that require both speed and accuracy. This framework suggests that performance can be controlled by either a connectionist knowledge base (implicit mode) or application of a symbolic conceptual mental model (explicit mode). Implicit control is fast but prone to error, particularly in early levels of skill acquisition. Explicit control is more accurate but slow to apply, and prone to loss by forgetting over a retention interval. We have found that reflection about how one is performing the task can be very beneficial following short periods of practice. However, it is often effective when learners are provided hints that direct their reflection in productive directions.

A computational cognitive architecture, CLARION, markedly different from other existing cognitive architectures, is developed in this work to simulate and capture a wide range of quantitative data that are related to the interaction, based on the above ideas. This will help us to predict (and ultimately optimize) training and learning processes. We carry out simulation experiments in the domain of process control tasks, as well as the domains of some other tasks, and generate new insight and interpretations that can further explicate the interaction between implicit and explicit processes. These anticipated outcomes (data, models, and theories) would provide a clearer and more comprehensive perspective on skill learning. Our models and

theories will be useful in better understanding skill learning (as well as in helping to improve learning processes). Our models and theories may also be useful in understanding individual differences in skill learning.

### **Potential Army/Military Applications**

It is expected that applications of this research for the Army will be in the area of training and human performance. A basic problem for the Army is how to ensure that novices in a Military Occupational Specialty (MOS) move quickly to achieve more advanced performance (and perhaps to expertise) as a result of their training. In addition, most training focuses on teaching conceptual knowledge rather than setting up the opportunity for substantial experiential knowledge. While this may be appropriate for some specialties, many specialties involve working with complex systems that are better learned initially through extensive experience than with lectures or textbook lessons. As service personnel gain in expertise, it may often become appropriate to focus more on conceptual knowledge. Our research will lead to some initial guidelines about 1) what types of training are most appropriate for learning complex systems, 2) what types of training are most appropriate for a given level of experience, 3) how MOS experts might best communicate their knowledge to MOS novices, and 4) individual differences in training performance and how these can be explored to enhance learning (or in other words, developing individualized, adaptive training). We would be interested in talking with our liaison officers about implementing and transitioning these ideas in the future.

### **Accomplishments**

We completed a large series of experiments in two different task domains: artificial grammar learning and process control. Both tasks involve learning a system that operates according to complex, difficult to learn rules. In the artificial grammar experiments, participants learn to spot poison can labels on a computer simulation of a starship that has been invaded by enemy agents. Identification of poison food labels requires learning to identify sequences of letters generated by a finite state grammar. Training for this task might include memorizing a diagram of the grammar (explicit training), memorizing cases (implicit training), or an integrated training that involves tracing cases through the grammar diagram. Principal findings include slow, but accurate responding when explicitly trained and fast, but less accurate responding when implicitly trained. Integrating or mixing types of training generally produced performance more accurate than implicit training and faster than strict explicit training. Simulations using CLARION have confirmed these findings. One interesting finding was that when exposed to both types of training, participants showed a tendency to prefer using the implicit mode. In the case of strict explicit followed by implicit training (a pattern that is common in many training situations, e.g., explicit schooling followed by field training) we noticed a loss of accuracy as learners shifted toward the implicit mode. We think training can be accelerated and this post-training drop eliminated by using the explicit conceptual knowledge to prime rather than compete with implicit learning. This notion is being tested in new experiments.

The process control task involves learning to control the temperature of a simulated nuclear reactor by controlling the number of fuel pellets. This task is known to be difficult to learn and difficult to explain how one accomplishes the task when it is learned. The results show that detailed reflection during task performance can interfere with learning. However, reflection following short periods of practice can be beneficial, especially when hints are provided about

how to reflect. Unlike the artificial grammar task, there are large individual differences in the ability to learn this task. Our participants were asked to formulate explicit rules or policies for performing the task as they were learning. On-going analyses of these policies are expected to reveal why many participants can never learn to control the reactor. Simulations using CLARION are also producing interesting hypotheses. Potentially, we can facilitate learning in these "failing" participants by instructing them on what to focus on when they reflect.

In the process, the cognitive architecture, CLARION, is being refined. It is shaping up to be a rather comprehensive framework for modeling and understanding skill learning in a variety of circumstances. Simulations using CLARION have provided interesting interpretations in a number of task domains and more simulations are under way.

### **Future Plans**

Given the limited amount of funding left for our project, we will be focusing mainly on analyzing gathered data and finishing off the CLARION simulation software development. We will also be working on a few major articles summarizing and analyzing our results. We also have plans for some additional interesting human experiments and further cognitive architecture development. These latter studies will need to be carried out with additional funding in the future.



## **BRO RESEARCH OBJECTIVE #2:**

*Provide fundamental knowledge to improve leader assessment and accelerate leader development.*

Research that falls under this heading provides concepts and methods for accelerating leader development, understanding and developing leader adaptability and flexibility, and discovering and testing the basic cognitive principles that underlie effective leader-team performance. Understanding the dynamics of small group leadership in face-to-face and distributed team environments is critical to this research objective as well.



## **Interactivity, Communication, and Trust: Implications for Leadership and Training in the Electronic Age**

**Contract #:** DASW01-00-K-0015  
**Institution:** University of Arizona

**Contract Dates:** 9/30/00 – 10/1/03  
**PI:** Judee K. Burgoon  
**Co PI's:** Suzanne Weisband &  
Joseph Bonito

### **Research Summary**

Successful leadership and team performance are built on a foundation of trust and effective communication between and among leaders and team members. New communication technologies such as email, text chat, cell phones, videophones, and teleconferencing are now pervasive in today's military as leaders and their teams now often work at a distance from one another. The 13 laboratory and field experiments in our research program to date seek to answer the question of how these new technologies affect a leader's ability to foster high trust, morale, and performance within his/her team. The guiding explanatory principle under test is the *principle of interactivity*: whether messages sent and received are coherently and tightly linked, create coordinated communication, and are marked by involvement, mutuality (sense of connection, receptivity, common ground, mutual understanding), and individuation (clear and detailed knowledge of sender and receiver identities). Technologies that enable proximal, real-time, and multi-sensory message exchange usually promote interactivity. The current round of investigations continues to address what forms of electronic communication help or hinder interactivity. It also considers whether task load—the degree to which a task is cognitively and/or physically effortful and demanding—alters interactivity and trust. Results speak to best communication practices that will help leaders maximize trust when trust is needed, dampen interactivity and trust when skepticism is needed, and prevent unintended negative consequences of using electronic media. We offer guidelines for leaders in selecting and managing communication processes and principles for training soldiers in their use.

### **Contributions to Basic Research**

This program of research contributes to knowledge and theorizing in the domains of leadership, group performance, trust, and human communication. It has direct implications for current organizational theories that address distributed "virtual" processes for accomplishing work as well. As work becomes more global and distributed, the whole nature of organizing will inevitably be modified. Such changes need to be guided by systematic empirical investigations rather than by anecdote and personal experience, which in many quarters form the primary source of "data." The theoretical principal framing our series of controlled experiments offers one coherent account for how new technologies utilized for distance communication impact communication patterns, trust, and leadership. The principle of interactivity proposes that the greater the degree of interactivity, the greater the trust. Where high trust is warranted, more interactivity should result in better performance. However, where skepticism and suspicion are warranted, such as when the task involves recognizing and deciphering invalid information or uncovering ulterior motives, greater interactivity may foster too much trust and result in poor performance. Degree of interactivity is therefore a key factor in predicting team trust and performance.

Our research program offers the richest explication in the scholarly literature of what constitutes interactivity and its possible effects. Original contributions include the focus on message exchange itself, and introduction of the multidimensional qualities of involvement, mutuality, and individuation as primary markers of interactivity. Our assessment of related communication qualities also offers new ways to gauge whether a team will develop and maintain the desired level of trust and performance. The use of both laboratory and field experiments and the use of a variety of tasks and forms of task load also increase our ability to generalize this research to other contexts and to discover those conditions under which the general principle may not hold. A final contribution is the development of a new web-based task, StrikeCom, which can be used for testing various forms of task load, group composition, and deceit, among other research objectives. StrikeCom has the virtues of engaging participant interest, simulating the kinds of tasks soldiers might confront and having the flexibility to modify such features as different map overlays, availability of a common situational awareness space, grid size, number of players, number of information assets, and reliability of the information that is returned.

### **Potential Applications**

Research under the preceding contract had established that trust and credibility are strongly influenced by the degree of interactivity during communication and that the communication process is itself affected by features of the technology in use. The implication is that leaders may select technologies that foster the desired level of interactivity and/or arrange conditions to ameliorate any drawbacks of technologies they are required to use. The research also provided evidence that frequent and explicit awareness of communication, especially during the early stages, improves team performance. The implication is that when leaders model and promote the exchange of task information and awareness of others, team members may be more motivated to work hard on behalf of the team. This further confirms the value of interactivity in achieving desired outcomes, in that awareness of the communication process and one another are direct evidence of the involvement, mutuality, and individuation that marks interactivity.

Army communication training for soldiers and leaders must include preparation for communicating in mediated settings. Leaders can be trained to analyze what degree of interactivity is needed for a given task or type of communication and to select the appropriate communication medium for the type of communication taking place. They can also be trained to be observant about qualities of the communication that is taking place between themselves and their team members and among team members. Subordinates can likewise gain heightened awareness of how mediated communication affects team trust and performance. If morale, trust, or performance appears to be waning, they can be trained in techniques to increase interactivity.

Protocols can also be developed for ensuring frequent and predictable interaction. Software tools can be adopted to aid this process. Protocols can also be developed that specify the "best practices" in terms of matching communication and information tools to desired objectives and predicted levels of task load. Such protocols can identify potential pitfalls to avoid or compensatory efforts that can be used so that negative consequences such as noncompliance, distrust and miscommunication do not occur under conditions of high time pressure, cognitive effort, inalertness, or fatigue. For example, periodic FtF communication may be recommended, or a shift from text to voice communication may be advised. Other potential applications are the development of software that will create a more visible form of social

awareness for team members and leaders who cannot communicate face-to-face so that collaborative work does not suffer.

### **Accomplishments**

The current investigations were undertaken to replicate and extend previous findings by using a variety of tasks conducted under several forms of task load. In the first experiment, team members completed business case studies under low, moderate, or high time pressure while communicating face-to-face (FtF) or via audio or video computer-mediated communication (CMC). The quality of members' communication and its interactivity was measured on 13 different indices, such as being involved and receptive to each other's ideas, mutual understanding and "connection," and having a pleasant, coordinated and smooth-running discussion. Outcomes included decision-making effectiveness and members' ratings of one another on trust. Audio communication emerged as superior for fostering interactivity and other favorable communication qualities (e.g., rich yet efficient information exchange, task focus, and positivity). Time pressure also made a difference: the higher the pressure, the less rich and analytical the communication, but the greater the coordination. Moderate time pressure was best for keeping tension and pleasantness at an optimal level. However, time pressure degraded decision-making effectiveness, especially in the audio condition, suggesting that with increased time pressure comes the need for more visual cues to coordinate task performance and gain feedback. The various modalities were equally effective in establishing and maintaining trust. These results imply that leaders would gain benefits from using cell phone and teleconferencing forms of communication as long as task load is modest, but should expect process and performance losses if time pressure increased.

The second experiment entailed a "get-acquainted" task during which half of the teams had a member who gave deceptive answers. This was considered a form of task load in that naïve partners needed to be alert to receiving invalid information relative to those whose partners were truthful. Team members discussed four topics intended to promote personal communication. Communication took place FtF or via one of three CMC modalities: text, audio, or audiovisual (AV). The same interactivity and trust measures were used as in Experiment 1, to which were added assessments of team members' truthfulness and expertise. Results showed that AV teams felt more connection and similarity and perceived team members as more truthful than did teams using audio or text communication. Apparently the presence of visual nonverbal cues contributed to mutuality with AV communication. As predicted, greater task load (introducing invalid information) reduced involvement, mutuality, and perceived truthfulness and expertise. The combination of task load and communication modality altered these relationships. Under low load (no deceit present), involvement was highest under audio and FtF communication (similar to the previous experiment). Under high load (deception present), involvement was much lower overall, especially under audio and text, but remained highest under AV. Trust showed the same pattern: highest trust under low load with the audio modality but lowest trust under high load with the same modality. Given that in the presence of invalid or deceitful information, team members should be least trusting, the implication is that the audio modality is the most sensitive to such differences and the best modality to use when there is some reason to doubt team members' truthfulness, motivations, or information. The second best modality for making fine discriminations was text. The least effective were AV and FtF, speculatively due to over-reliance on misleading nonverbal visual information available in those

modalities. Overall, these results confirm that task load and modality together influence the communication process in complex ways.

The third experiment utilized our own revised version of the familiar Desert Survival Problem, in which team members must rank-order salvageable items from their overturned jeep in terms of survival value. Pairs interacted FtF or via text, audio or AV. One member in half of the teams was asked to provide bogus arguments and evidence contrary to expert recommendations, which both team members read beforehand in the form of encyclopedic information on desert survival. In this experiment, modality did not directly affect the communication process but task load did: Higher load (presence of deceptive information) reduced involvement and mutuality, trust, other credibility assessments, and decision quality. The implications are that communication processes “register” invalid information, even if at an unconscious level, by producing poorer communication processes, which in turn are correlated with loss of trust, reduced credibility, and poorer decisions. A further, follow-up analysis of the data from these last two experiments revealed that FtF communication is still the most expected and positively regarded modality for communication, in part because achieving mutuality and smooth, productive interaction is easier with FtF communication. However, the CMC conditions are also well regarded when task load is low. The implication is that if leaders and team members can manage the communication process itself to be smooth, coordinated, and useful and to keep involvement up, then any CMC modality can be used effectively under routine (low load) conditions.

The fourth experiment examined task load by manipulating the complexity of information that team members had to digest before completing the DSP task. The low load version of “Surviving in the Desert” was the same “encyclopedic” version used in the Experiment 3, which had a 12<sup>th</sup> grade readability level and moderate level of linguistic complexity. High load versions were written using far more technical jargon and details from a military field manual, with a college level of readability and more complex vocabulary. Results revealed that adverse effects from high task load depended on what form of communication was used. Whereas with audio communication the high-load technical information created greater effort, with FtF communication the high-load technical information made the task seem less effortful than the low-load version. Higher load also created greater trust, perhaps because the team members who used it seemed more knowledgeable. Modality did not affect trust directly but did affect all communication measures. As expected, involvement and mutuality were lowest with text communication. Team members were also judged as the least sociable, competent, and dominant under text and the most so under FtF and AV. Overall, then, text was the least desirable modality for conducting this decision-making task, suggesting that leaders may experience similar declines in interactivity, high-quality communication, trust and team performance when text is the chief means of communicating. Interestingly, task satisfaction was highest under the combination of audio and low task load, indicating that the audio modality’s benefits are greatest when it is not used for overly complex information transmission.

The fifth experiment again examined task load as a form of time pressure, this time by comparing synchronous (real-time) communication versus asynchronous (delayed transmission) communication. The former used text chat as the means of communication; the latter used email. Team members again conducted the DSP, either during a single series of same-time exchanges or over the course of a week. As expected, synchronous interactions were judged higher on involvement, mutuality, sociability, and composure, and generated higher truth bias

(overestimating truthfulness) than did the asynchronous condition. Although trust did not differ between the two conditions, those in the synchronous condition were also less suspicious and less motivated to monitor their partner. These findings strongly support the interactivity principle—real-time communication promoted greater more involvement, mutuality, positive regard, and belief in the other's truthfulness. Simultaneously, it sapped team members of the motivation to critically evaluate incoming information. Implications for leadership are that same-time communication is ideal for promoting conditions of high interactivity and trust but detrimental when the objective is critical analysis and evaluation of information.

The sixth, seventh, and eighth experiments utilized C3I game—first Scudhunt, then an original game we developed called BusterBunker and finally the most recent game we developed, called StrikeCom. The general task entails 3- or 4-person teams controlling different information assets that they use to search a hostile area. After sharing their respective information returns from their assets, the team develops a unified strike plan to eliminate enemy strongholds. This task was conducted under the same four modalities as used previously. In some conditions, one team member introduced deceptive information. In others, teams either had a designated leader or were encouraged to work together and select a leader. Initial results have confirmed that greater task load (in the form of invalid information) reduces group performance. In other words, teams with bad information fail to ferret it out and discount it. Teams with emergent leaders also performed better than those without or those with designated leaders. Additional analysis is in progress.

A ninth investigation considered how communication awareness affects leadership, trust and team performance. Interactivity is an essential mechanism for achieving four types of awareness: activity (knowing what others are doing), availability (knowing when others are available to meet or talk), process awareness (knowing how various pieces of the process fit into the big picture), and social awareness (having the individuating information to know each member's social situation). Effective leaders promote these forms of awareness, along with participant involvement and mutuality, by structuring tasks and communication modalities to achieve them and by engaging in behaviors that signal trust, respect, and concern for others. Achieving these objectives becomes more complicated with distributed communication. Project teams that were geographically dispersed worked interdependently on a complex task (high task load) using electronic communication (and limited FtF) over the 36-day project period. Graduate students served as team leaders. Results confirmed that greater awareness was a significant predictor of team performance. High-performing teams communicated more frequently (i.e., demonstrated higher interactivity). Leaders who encouraged more daily contacts and more awareness among team members were more successful.

A tenth investigation considered whether designated leadership would differ from team-selected (i.e., emergent) leadership and whether communication modality (FtF, web conferencing, or no interaction) would affect performance. Results showed that emergent leaders created more awareness than assigned leaders. As with the prior experiments, FtF interaction created greater mutuality ("we-ness") than did the web or no interaction condition, but performance was actually highest in the web condition with the emergent leader. This suggests that FtF may be preferable for social objectives such as creating group solidarity and morale but that CMC may actually be preferable for task focus *if* the team has an emergent (rather than assigned) leader structuring the interaction. Absent that, the web format had the worst performance, worse than teams that did not interact. Other analyses are pending.

## Final Summary

Work teams that communicate through new computer technologies fare no worse (or perhaps no better) than teams that hold face-to-face meetings. It all depends on what the task is and what the team's objectives are. Our series of studies focusing primarily on voice-only, audio-visual, and text interfaces, and on several collaborative tasks, found that the degree of interactivity that team members achieve affects team trust and performance, irrespective of the type or difficulty of the task. Characteristics of interactivity include how connected participants feel toward each other, how involved they are, and the extent to which they perceive each other having the same goals. Collaborations that are perceived as highly interactive reflect favorably upon perceptions of the participants and are associated with other positive communication qualities such as high quantity of information, efficiency, critical analysis, and smooth, relaxed and pleasant interaction. These qualities in turn contribute to strong team performance. Some technologies make high interactivity more likely than others and result in higher team trust and performance. For example, same-time voice communication creates mutual feelings of connection, understanding, and involvement; leads to richer and more fruitful discussions, builds trust, and results in better decision-making. More cognitively challenging tasks may benefit from the availability of visual as well as auditory channels to clarify meanings, signal understanding, and exchange feedback. But even interfaces that are less "interactive" (e.g., email) can still be perceived as fairly interactive, under the right conditions and with the right guidance from leaders.

Not all tasks profit from interactivity, especially when longer, more thoughtful deliberation is needed, or potentially invalid information is being shared that needs greater scrutiny. In these cases, less interactivity—greater detachment and sense of separation—will lower trust but may result in better decision-making. Real-time technologies such as instant messaging, cell phones and voice communication may actually create mindless information processing and hasty decisions as compared to older technologies such as different-time bulletin boards and text exchanges.

Our research did reveal, somewhat unexpectedly, that the degree of mental or physical effort required for a task has variable effects on communication, trust and performance. People are often able to compensate for task difficulties, and, for some aspects of communication, moderate difficulty is preferable to low difficulty, probably because it keeps people more alert and caught up in the task. But some interfaces, such as text, which requires typing rather than speaking, require more mental effort to use and therefore may be best matched with less "taxing" tasks. With difficult tasks such as comprehending more complex information, text-based interfaces also seem less interactive, making them inadvisable choices if trust and group morale are at stake. Face-to-face and visual communication, however, are not the best choices if the task entails recognizing and assessing invalid information.

Because the United States Army funded this research, there is considerable interest in how these results are informative for military applications. The answer depends to some extent on which outcomes are desirable. Imagine that one wanted incoming information to be monitored for its veracity—in such cases, audio communication seems to accomplish this, as does bulletin board style communication. On the other hand, if one desired simple information exchange (e.g., orders or commands that should not be questioned), then chat-style text might fit

the bill. In the end, the complexity of communication is affected by the technology that teams use. It is critical that technologies be fitted to desired aims and outcomes and that leaders either select appropriate technologies or take measures to offset any downside risks of using a given technology. Informal leadership that emerges within a team, rather than formal leadership, may have the most influence on the resultant communication process and outcomes. Designated leaders are well advised to monitor such interactions and to encourage frequent interactions among distributed team members.

## **The Leadership Formula: P x M x D**

**Contract #:** DASW01-01-K-0004  
**Institution:** The Center for Outstanding  
Leadership

**Contract Dates:** 09/01/01-03/01/04  
**PI:** Dr. Reuven Gal  
**Co-PI:** Dr. Micha Popper

### **Research Summary**

The present study examines leadership development processes through a field study in the Israeli Defense Force (IDF). The conceptual framework suggests that leadership is a function of a given potential (P), a relevant motivation (M) and developmental processes (D). These three components comprise the “formula” (P x M x D) for being a leader. This “formula” and the theoretical framework from which the formula is derived, expand the view on leadership, by emphasizing internal aspects, including personality predispositions, motivational needs and developmental processes, that give rise to leadership emergence and functioning. Our argument is that only those who have the potential represented by certain “ego resources” (such as high self-efficacy and low level of anxiety), who have a strong motivation to lead, and who are capable of personal development can become leaders.

Guided by this conceptual framework, we have three main research hypotheses. First, ‘leaders’ will have higher potential (“ego” resources) compared to ‘non-leaders’. Second, ‘leaders’ will have higher motivation to lead than ‘non-leaders’. Third, ‘leaders’ will report more ‘leadership-shaping experiences’ (LSE) to have occurred in their early childhood and adolescence periods, than ‘non-leaders’ and they will be characterized by higher levels of “openness” to new experiences than ‘non-leaders’.

This study is based on a comparative examination of several samples of IDF soldiers (from Infantry and Armour units) undergoing basic-training. By distinguishing ‘leaders’ from ‘non-leaders’ and subsequently assessing various P, M and D measurements, this field study will enable the examination of our three categories of hypotheses related to the leadership formula: potential, motivation and development.

### **Contributions to Basic Science**

The present study contributes to basic research in the area of leadership development by addressing conceptually and empirically three leadership concepts: leadership potential, motivation to lead and leadership development. These leadership concepts are tested empirically in our study by using existing psychological instruments (to test the **P** component) and by constructing and forming new instruments (to test the **M** and **D** components). We have expanded the “motivation-to-lead” concept, a concept scarcely examined in the literature, both substantially and technically. We have constructed three developmental-leadership assessment tools: an openness to experience questionnaire, a LSE interview and a LSE questionnaire. Finally, we have formed a questionnaire identifying ‘leaders’ and ‘non-leaders’.

## **Potential Army/Military Applications**

This research is conducted in the Israeli Defense Force (IDF). Unlike civilian organizations, where leadership is diffused in the manager's functions and formal authority, in the military 'net leadership' is much more prominent and, in fact, is an essential driving force that generates the soldiers' readiness to risk their lives. Furthermore, within the military, the distinction between 'leaders' and 'non-leaders' is much more apparent than in most other institutions. This distinction is somewhat contaminated, however, in those military organizations (such as the U.S Army), in which the differentiation between officers and non-officers is done 'institutionally' (i.e. through military academies), rather than 'naturally' (namely, through a gradual selection process). A unique example of the latter type is the IDF: Starting on an equal footing, all Israeli conscripts undergo a continuous selection process during their initial training period. Through this prolonged process emerge those who eventually become officers or NCO's. This unique situation makes the IDF an extraordinary natural laboratory to examine leadership development. Moreover, this field study is conducted on two different army corps, Infantry and Armor, in order to examine whether they reflect different leadership-forming processes.

Overall, this study may provide a unique opportunity to understand how 'leaders' differ from 'non-leaders', what is it that makes the 'net-leadership', and how it develops. Furthermore, our research may unravel some of the mysteries related to the nature-nurture origins of leadership, as well as suggest some important and practical implications related to leader selection and development (i.e. training) in any modern military.

## **Accomplishments**

So far, we have completed the first round of questionnaires and interviews. By February 2003, we obtained questionnaires from 402 IDF soldiers and we performed 60 LSE interviews. We have finished analyzing the leadership potential (P) questionnaires and the results are very promising. All potential variables ("ego resources") significantly differentiate between 'leaders' and 'non-leaders'. These results were presented on June 17-18, 2003 in the IPR meeting at Fort Leavenworth. An academic journal paper, based on these results, is already in its final version.

We now are analyzing the quantitative data concerning the Motivation to Lead (MTL) element and the Development element (D). The initial findings are, again, promising. There are significant differences in the motivation to lead between soldiers defined as 'leaders' and those defined as 'non-leaders'. Also, as expected, soldiers defined as 'leaders' are more open to new experiences than those defined as 'non-leaders'.

The qualitative data concerning development issues is now being analyzed.

In May 2003 we started the second round of questionnaire administration. In this phase we return to our original subjects, and administer the three questionnaires that measure those attributes that are conceptually dynamic and may change over time (General Self-efficacy, Motivation to Lead, and Openness to Experience).

### **Future Plans**

We plan to finish the second phase of questionnaire administration by September 2003 and the follow-up interviews by December 2003. We will continue analyzing the data and will draw conclusions concerning each of our three components (P, M & D) as well as the interrelationships between these components. Finally, we are seriously thinking about developing further studies based on the promising data we have obtained.

## Leadership: Enhancing Team Adaptability in Dynamic Settings

**Contract #:** 1435-04-03-CT-71272

**Contract Dates:** 01/24/03-01/23/05

**Institution:** University of Maryland – College Park

**PI:** Dr. Katherine J. Klein

**Co-PI:** Dr. Steve W. J. Kozlowski,  
Dr. Yan Xiao

### Research Summary

The U. S. Army Vision is to transition the Army into an Objective Force that is strategically responsive, dominant at every point on the spectrum of operations, and capable of transitioning across mission requirements without loss of momentum. To fulfill its missions, the Objective Force of the Army must be responsive, deployable, agile, versatile, lethal, survivable, and sustainable.

Such responsiveness, deployability, agility, and versatility are the hallmarks of *adaptive team performance* – the ability of team members to individually and cooperatively apply their knowledge and skills to the resolution of urgent, complex, novel, and ambiguous problems in dynamic work settings. In such settings, rigid adherence to standard operating procedures and routines is impossible. Adaptability is essential.

*What then can leaders do to develop and enhance the adaptability that is so essential for the Objective Force?* Existing theory and research offer few explicit guidelines. Scholars reveal increasing awareness of the importance of individual and team adaptability for the Army of the Future – indeed, for the workplace of the future, yet empirical studies of adaptive team performance within dynamic work environments are virtually nonexistent.

To begin to fill this gap, we have begun a multi-level, multi-method research program designed to illuminate the influence of individual differences, team characteristics, and leadership on individual and team adaptive performance within a dynamic work environment. Our research addresses three questions:

- How do *individuals* acquire the knowledge and skills necessary for adaptive *individual* performance?
- How do teams comprised of adaptive individuals acquire the *shared* knowledge and skills necessary for adaptive *team* performance?
- What can *leaders* do to enhance these processes?

### Contributions to Basic Science

Our research will contribute to basic science in four key respects. First, our research will shed new light on team leadership. Existing models of leadership focus on the effects of leadership on individual employees or on the organization as a whole. Theory and research on team leadership – on the ways in which leaders influence team members' interdependent,

coordinated work performance – is very limited. Our research promises to clarify the leader traits, behaviors, and strategies that enhance team performance.

Second, our work will extend research and theory on how individuals operating in complex and dynamic team settings learn in ways that contribute to both individual and team effectiveness. By better understanding this process of learning and adaptation, we will be able to show how leaders can develop more adaptive and effective teams.

Third, by examining individual and team learning and adaptation over time, we will contribute to multilevel theory and research methods, clarifying appropriate strategies for multilevel theory-building and research on processes occurring over time. Such longitudinal processes have relatively rarely been considered in multilevel theory and research.

Finally, by employing qualitative and quantitative field research methods as well as experimental laboratory research, our research will provide an example of the use of complementary research strategies to strengthen and cross-validate research conclusions.

### **Potential Army/Military Applications**

Our research will identify theoretically driven, empirically grounded, and experimentally validated antecedents of individual adaptability and team adaptability. In addition, our research will yield specification of leadership behaviors, capabilities, and skills that critically influence the development of individual and team adaptability. We anticipate that our findings may be put to use in selecting individual soldiers, teams, and leaders most likely to perform adaptively in dynamic settings. Further, our findings may suggest training interventions and intended training outcomes to enhance the adaptive performance of individuals, teams, and leaders.

### **Accomplishments**

The first phase of our research program is now underway, with one focus of activity centered on the Trauma Resuscitation Unit of the Baltimore Shock Trauma Center and the other focus of activity centered on the Adaptive Performance Training Lab at Michigan State University.

We are in the early stages of qualitative research in the Trauma Resuscitation Unit of the Baltimore Shock Trauma Center. There, we have conducted background interviews with nurses and attending surgeons regarding the resident program that is the focus of our research at the Shock Trauma Center. These background interviews provide the groundwork for more intensive qualitative data collection in the coming months, as described below. In preparation for further field data collection, we have reviewed and analyzed background documents regarding the Shock Trauma Center as well as interview data collected in our prior research, but not previously analyzed in depth.

Initial work at the Adaptive Performance Training Lab has involved an examination of the scientific research literatures that pertain to team leadership functions, team development processes, and performance adaptability. We are in the process of abstracting and compiling that work; distilling core team leadership functions; and synthesizing new team leader functions that promote individual learning, team development, and adaptive performance capabilities. The

research model that will result from this effort will be used to specify the core constructs, key processes, and primary outcomes that will be examined in subsequent lab experiments.

### **Future Plans**

In the next four months, we will conclude our qualitative study of individual and team adaptive performance in the Trauma Resuscitation Unit of the Shock Trauma Center. Our qualitative research is designed to ground our subsequent quantitative examinations of leadership and individual and team adaptability in a real-life dynamic setting. On the basis of our qualitative findings, we will: (a) develop additional hypotheses regarding the antecedents of individual and team knowledge acquisition and adaptive performance; and (b) refine and develop survey and other measures that will allow us to test our individual- and team-level hypotheses using a quantitative, longitudinal, survey methodology in the Shock Trauma Center.

During the remainder of the upcoming year, we will conduct longitudinal survey research to test our hypotheses regarding the antecedents of individual and team adaptive performance. We plan to gather data from individual residents and resident teams (that is, survey data regarding individual residents and regarding each team of residents as a whole) at least two times each month (early in the life of the team and late in the life of the team). Our goal is to allow longitudinal assessment of the development of individual knowledge and skills and of the development of shared team knowledge.

Development of the research model, specification of primary experimental factors, and operationalization of measures is expected to be completed over the next four months. We will then initiate lab research that examines antecedents of individual learning and the development of adaptive capabilities.

# **Learning Leadership Skills in Distributed Training Scenarios: Diagnosing Strategies in Scenarios Using Latent Semantic Analysis**

**Contract #:** DASW01-00-K-0017

**Contract Dates:** 9/1/00-8/31/03

**Institution:** George Mason Univ/Univ of Pittsburgh

**PI(s):** Christian Schunn

## **Research Summary**

The primary objectives of this research are to (a) test a theoretical model of expertise in complex tacit knowledge domains like leadership and (b) test a diagnosis and training approach that is based on that theoretical model of expertise.

The theoretical model being applied to leadership assumes that one important component of expertise is the effective and appropriate use of strategies. Expert strategy use generally differs from novice strategy use along five dimensions (Lemaire & Siegler, 1995; Schunn & Reder, 1998). In order to provide appropriate training to a novice, one has to diagnose the particular type of strategy use problems exhibited by the given novice. The particular problems include (a) missing strategies entirely, (b) under-using generally effective strategies, (c) poorly executing strategies, and (d) executing good strategies at the wrong times, (e) failing to adapt strategies to a changing environment.

Diagnosing strategy use in complex domains like leadership presents a difficult challenge. Thus, the secondary objectives of this research are to explore mechanisms for automatically diagnosing strategy use and larger scale problems in patterns of strategy use (along the five described dimensions) in complex domains, particularly the strategies found in written responses. If such a method can be developed, then this strategies-training approach can be effectively applied in distributed, distance-training situations.

## **Contributions to Basic Science**

The current work advances both our knowledge of the psychology underling expertise and computer science of intelligent tutoring. The model of expertise that I am testing has only been demonstrated in very simple domains (like child mathematics learning), and it is unclear whether models of expertise from very simple domains will be applicable to expertise in complex domains like platoon leadership. Second, intelligent tutoring systems have traditionally limited the ways in which the person could interact with the systems. Recently, approaches have attempted to include more natural interactions, like spoken and written dialog interaction. However, much basic science needs to be done in developing methods for parsing spoken or written dialog. One such open problem is diagnosing strategies and the proposed work tests a very new scheme for solving this problem.

## **Potential Army/Military Applications**

The application of our intelligent tutoring work is clear: if the automatic strategy identification methodology works, we can build a successful tutoring system. By using it, then, we will have developed a powerful methodology for intelligent tutoring in many complex, ill-

defined domains which are found in many military settings, including the platoon leadership setting being studied directly.

We also expect to learn more about what common strategies can be effectively applied across a wide range of platoon leadership situations. This knowledge in itself could also be applied to other, more traditional training methods beyond the particular automated method being pursued here.

### **Accomplishments**

To develop a base set of diagnostic and training examples, we have expanded the original set of 15 platoon leadership scenarios in the TKML (Tacit Knowledge Military Leadership) to 50 scenarios. These 50 scenarios cover the main types of skills typically associated with platoon leadership. The new scenarios were adapted from scenarios presented in the Army Leadership Tacit Knowledge Corpus. Because these scenarios are to be used for written responses and our goal is to diagnose particular leadership strategies in the responses, the scenarios were designed to require a single strategy response rather than a long list of different strategies.

In preparation for the LSA phase of the project, we acquired the specialized computer and software to run LSA and successfully conducted basic test runs with LSA. We then tested LSA using various military leadership databases as input, including the vignettes from the Army Leadership Tacit Knowledge Corpus, the Army Military Leadership Field Manual FM 22-100, and numerous text documents related to military leadership found on the web (many of which can be found at <http://www.au.af.mil/au/awc/awcgate/awc-ldr.htm>) producing a total text corpus of 0.5 million words.

We collected data from 25 ROTC cadets, with each cadet generating text responses to at least 10 open-ended scenarios. We developed a set of 13 leadership strategies (e.g, planned action, authoritarian, avoidance, punishing, seek additional information) based on cards sorts of possible options in the Platoon TKML ratings task, and then conducted some testing of these strategies on the open-ended text data.

To develop an automatic method for coding strategies in the open-ended text responses to be used in the intelligent tutoring system, we went through a number of steps. First, a research assistant generated an example of how to implement each of the 13 strategies in each of 10 scenarios (selecting only 10 as a trial set). These implementations were called scenario-strategy-ideals. Then LSA compared each open-ended response to these scenario-strategy-ideals and assigned the response to the strategy category with the best matching ideal. This method proved to be better than chance, but well below human coding accuracy and well below usable levels for later use in intelligent tutoring.

Through a gradual process of refinement in coding actual open-ended responses using these 13 strategies, we narrowed the set down to 10 general strategies that could be coded more reliably. We then asked a different set of 28 ROTC cadets to generate implementatons of each of the strategies in each of the scenarios (5 strategies for 5 scenarios for each given cadet). Because there appeared to be multiple legitimate ways to implement a given strategy in a given scenario, we wanted data on the variety of ways this could be achieved. Coders carefully went through this forced strategy data to make sure that the cadets did indeed respond with the given strategy

in the given scenerio context. Only a small proportion of the forced data was removed due to not implementing the indicated strategy.

With the forced strategy data in hand, we then reconducted the LSA analyses. This time the LSA strategy coding results were better but still below human coding accuracy—approximately 50% of human performance. Exploration found that the richness of the text input did not matter, nor did many variations of the matching algorithm. It is our current belief that approaches like LSA which do not use structural information of the text are not well suited for strategy classification in complex domains. We built a prototype of the tutoring system (using a web-based linux system using MySQL and PHP). However, without accurate automatic strategy classification, we chose not to test the system in a training situation.

To study the effects of expertise on these strategies, we also collected data on the open-ended task from undergraduates completely unfamiliar with either leadership or the Army. We also collected comparable data from 60 experts (lts, capts, majors) last summer from two military bases as part of Umbrella week activities. We found that expertise in leadership does consist of having better strategies, selected with better base-rates, and selected for particular problems in a more appropriate fashion.

To study the issue of quality of strategy implementation, we selected responses from each of the groups and gave them to a new group of experts (this time 25 lts, capts, majors from one base during Umbrella week), and asked them to assess how good a job the person did of implementing the given strategy (as we coded it) regardless of whether that was the best strategy to use in the given scenario. Thus far, we have not seen noticeable differences in the quality of implementation, but we have only begun to analyze this data.

We have also conducted several basic research studies to examine the ways in which adapting strategy use to changing environments plays a role in expert performance. In the first study, we found that there are individual differences in how well people adapt their strategy use to changes in how well the strategies worked (using a simple problem solving task in which we had perfect control over strategy effectiveness). In the second study, we showed that the individual differences were related to how explicitly aware people were of the changes in the environment, but that unaware people did adapt to some (lesser) extent. We also showed (surprisingly) that working memory was not related to adaptivity. In the third study, we showed that adaptivity level was not related to motivational levels, neither intrinsic (as measured by self-report) nor manipulated (performance paid or unpaid). In the fourth study, we found that these individual differences were stable within different measures of adaptivity in a given task, and across two different tasks (a simple problem solving task and a 3-d navigation task). In the fifth study, we found that adaptivity levels were uninfluenced by the insertion of other adaptivity learning tasks or filler time, consistent with an implicit model of learning strategy preferences. Overall, we have an interesting juxtaposition of strategy choice learning which appears to be influenced by explicit awareness, but not influenced by factors typically associated with explicit learning mechanisms (e.g., interference, working memory).

### **Final Summary**

Overall, we partially validated our model of expertise. We found that expertise in platoon leadership consists of having better strategies, understanding which strategies are better

overall, and knowing when to use those strategies. Contrary to expectations, we did not find that experts implemented the same strategies more effectively, but we are still exploring this issue.

We have also elaborated our understanding of how people adapt their strategy use to changing environments. We found out that there appears to be stable individual differences in how well people adapt their strategy selections to changing environments. We have also produced a puzzle for what underlies this strategy adaptivity. We learned that it has both implicit and explicit components and that the explicit component is required for rapid adaptivity. However, we found that working memory capacity and memory interference factors, which we expected to influence adaptivity, do in fact not influence adaptivity.

At the level of intelligent tutoring, we explored one approach to automatic identification of strategies and found that it was able to make some progress on the problem, it was not likely to reach practically-useful levels. Since this kind of approach is still in its rapid-growth phase in the research community, failures like the current one in applicability of the approach are likely to be very informative to other researchers in the area.

We did develop a methodology for identifying higher-level problems in strategy use (related to our different dimensions of strategy expertise), and this methodology did prove useful and will feed into future intelligent tutoring work.

# **Developing Effective Military Leaders: Facilitating the Acquisition of Experience-Based, Tacit Knowledge**

**Contract #:** DASW01-00-K-0014  
**Institution:** Yale University

**Contract Dates:** 9/01/00 – 9/30/04  
**PI:** Robert J. Sternberg

## **Research Summary**

Army officers are facing a leadership environment that is more diverse and more rapidly changing than ever. This diversity and change stems from an increased variety in the nature of missions that Army personnel must undertake, an ever-widening array of sophisticated technology used to conduct these missions, and shared decision-making capability across ranks when mission objectives are rapidly modified.

This requires that officers learn from their experiences quickly and efficiently. The primary goal of the “developing effective military leaders” project, therefore, is to explore ways to improve people’s ability to acquire knowledge from their experiences and to use this knowledge to solve practical problems. We have constructed three different sets of thinking exercises, all of which are based on Robert J. Sternberg’s theory of practical intelligence and tacit knowledge, in order to identify a “best practice” for enhancing experience-based learning. Each intervention targets a different aspect of tacit knowledge: (a) the conditions that must be met to make optimal practical decisions; (b) the actions that best correspond to particular conditions; or (c) both. This work represents an extension of previous research indicating a relation between experience-based (or tacit) knowledge and occupational performance in that we are attempting (a) to better characterize the cognitive processes that occur while people use tacit knowledge; and (b) to understand how these processes may be facilitated through training.

## **Contributions to Basic Research**

A theory that attempts to explain human functioning in everyday life is by necessity complex and multifaceted. Testing and improving this theory is a long process, in which the theory is addressed piece by piece. The major contribution of the current work to basic science is the illumination of a previously unexplored piece of Sternberg’s triarchic theory of intelligence. The piece we are exploring outlines the cognitive processes involved in acquiring tacit knowledge from experience, the problem-solving skills involved in solving complex practical problems, and the interaction between knowledge and problem solving in expert performance. We will test whether a set of instructional thinking exercises based on this piece of the triarchic theory can “speed up” the experience-based learning process and improve practical problem solving. We expect the results from this test to lead to additional refinement of the triarchic theory and contribute to a growing knowledge base with regard to expertise and leadership development.

## Potential Army/Military Applications

Because the complex and ever-changing nature of job environments precludes teaching leaders what must be done in every problem situation, leadership instruction must instead provide leaders with the skills to use experience as their career-long mentor and source of feedback. We expect our research findings to have specific implications for the design of leadership development course materials delivered via distributed-learning methods. We also expect that our research findings will provide an effective target for more intensive classroom-based leadership development efforts.

## Accomplishments

Our accomplishments over the past year involve instrument development, data collection, and preliminary data analysis. First, over the summer of 2002, we developed two new case study scenarios to assess platoon-level tacit knowledge. The scenarios were designed based on tacit-knowledge theory with the help of military personnel (LTC Mike Prevou and LTC (Ret.) Chuck Powell) to make them more meaningful for Army officers than previous scenarios. Also during this time we audited a three-day segment of the Tactical Command Development Course at Ft. Leavenworth in order to fine-tune the thinking exercises in our instructional interventions, making them more compatible with the kind of practical-problem solving exercises conducted during existing command training.

Second, in August of 2002, we conducted a pilot study with 1st Infantry, 1st Battalion at West Point to assess the fidelity of our case study scenarios and the feasibility of our instructional interventions. During this study we worked with 23 non-commissioned officers, who completed the interventions and rated the quality of the newly developed scenarios. Our discussions with the NCOs led to important revisions of (1) the intervention thinking exercises to make them less technical and more accessible to Army participants; (2) the problem-solving questions following the case study scenarios, again to make them less technical and more accessible to Army participants; and (3) the paper-and-pencil format, changing it from requiring written answers to requiring answers provided over digital voice recorders. Participants noted that the writing demand in our interventions was quite high and that being able to think aloud would be more natural.

Third, in October of 2002 and March of 2003 we collected data at Fts. Sill and Drum, respectively, working with 101 officers (LTs, CPTs, MAJs, and LTCs) before access to troop support was terminated due to deployment to Iraq. Since that time, we have worked to transcribe the digital voice files created by participants, to enter data from written materials, to develop a comprehensive scoring rubric for scoring open-ended case study responses, and to begin analysis of the data collected.

Our initial findings indicate that officers of all four ranks felt that they learned something from the interventions, that the interventions were useful for understanding how to learn from experience, that the interventions were relevant to the leadership problems they typically face, and that they plan to use future experiences as opportunities for learning. These positive attitudes were mirrored by performance benefits experienced by officers in the intervention conditions. Overall, interventions allowed, on average, officers to maintain performance from pre-test to post-test, whereas the performance of officers in the control condition went *down*

from pre-test to post-test. In addition, interventions were differentially effective in maintaining performance, in accordance with predictions. These differential effects could not be explained by differences in cognitive ability, attitudes towards leadership instruction, or differences in pre-test scores. We do not have an explanation at this time for why performance went down in the control group, but we do not have any reason to suspect that control group was different from the intervention groups in any systematic way. Finally, captains gained the most from participating in an intervention, with lieutenant colonels/majors gaining slightly less, and lieutenants showing a decrement in performance after participating. It appears that a well-developed knowledge base, combined with a newly developing set of reflective thinking skills is required to maximally benefit from the interventions.

### **Future Plans**

Our plans for next year are twofold. First, we plan to continue collecting data with Army participants, once troop support is again permitted. We would like to work with an additional 140 officers in order to test our hypotheses with adequate statistical power. Second, we plan to design an auxiliary experiment to be implemented with college students. In this experiment, we will test the same hypotheses as with the Army participants but we will use a more extensive, classroom-based intervention with long-term follow-up on participant performance after intervention.

## **Distant Leadership Under Stress**

**Contract #:** DASW01-99-K-0003

**Institution:** University of Maryland, Baltimore

**Contract Dates:** 08/01/99-07/31/02

**PI's:** Yan Xiao

**Co-PI's:** Colin Mackenzie & Katherine Klein

### **Research Summary**

The overall objective of this project is to investigate leadership effectiveness when leaders are distanced from the team. Since the role of leadership in team performance is important, understanding how leadership impacts team performance is important to military as well as to civilian organizations. With the widespread use of electronic communication technologies, it has become essential to establish a theoretical and empirical basis for predicting how new communication technologies may impact leadership and team performance. The specific aims of the research program are: (a) to develop a matrix of leadership functions and situations in which specific functions are needed; (b) to develop a leadership model which prescribes the nominal processes through which a leader controls and influences team activities, either co-located or at a distance; (c) to develop leadership measures applicable to leadership in a dynamic, team environment; and (d) to conduct a series of prospective studies in a real, event-driven, stressful environment to evaluate the impact of various communication modalities on leadership using the measures developed.

### **Contributions to Basic Science**

Our research has several unique features as compared to previous leadership research. First, our empirical data is from a real environment. Second, our study environment allows direct observations and audio-video recordings of real team activities under stressful situations and the manipulation of communication modalities between leaders and team members. Third, the task situation characteristics (high-risk, high-tempo) provide a basis for studying highly reliable, rapidly assembled and flexible teams. Fourth, the empirical research triangulates three types of data sources: interviews, video analysis, and briefings with experiment subjects.

This project made two key contributions to team leadership basic research. First, our research established the phenomenology of team structures and how the structures adapted to various factors. Through analysis of communication structures, we examined changes in team structures due to the impact of distant leadership, team experience, and task urgency. We proposed a set of team structure archetypes as a way to reflect the impact of team experience, leader location, and task urgency. Previous studies on leadership and team performance have not examined team structure in this manner. Instead, research has typically assumed only two team structures: 1) undifferentiated (such as self-managed teams), or 2) a leader-follower/s dichotomy.

Second, the research provided further evidence of dynamic team leadership functions among team members. In particular, when the team leader is distant to the rest of the teams, team members were found to provide more team leadership. Also, based on debriefing materials and verbal communication, we demonstrated that leaders and teams adapt their structure both across sessions and within sessions. We believe that measuring team structure is an effective way to

capture distant leadership and that the findings associated with team structure will have direct implications for training and team-technology design.

### **Potential Applications**

We anticipate our efforts will fill a void in the literature. In particular, our research will help us to understand leadership processes in the context of team performance and provide a basis for future training programs and other interventions to enhance team performance, especially when leaders and members are separated by distance.

First, team structures in dynamic task settings are fluid. To match the changes in team structure, distant leaders should be provided with maximum control of communication topologies. Due to rapid changes found in some work settings, teams may encounter dynamic task conditions in which they have the dual goal of successful training and performance. Our experimental results suggest that team leaders adapted how they communicate with their team members. This ability to control and rapidly adapt configurations of communication channels (who talks to whom and who can hear what) is critical. The leaders in our research showed preference for a hierarchical communication structure, but would alter that structure when task urgency was high or the team was unexperienced working together. Secondly, leadership development, as built-in in the teams studied here, should be viewed as a necessary adaptation strategy for those teams that face highly fluctuating task demands. In the case of trauma resuscitation teams, they may have to be split up to treat more than one patient, and necessarily junior members have to enact leadership. In distant leadership conditions, some of the functions need to be fulfilled by people other than the leader. Worded differently, when a team is likely to encounter highly dynamic tasks, the team members should expect to provide leadership even though they may not be designated as the team's leader. Thirdly, leadership should be assessed not only for the team performance achievement, but also for allowing leadership development among team members.

### **Accomplishments**

We have accomplished all major tasks for the project. The final report was submitted to ARI. Through several iterations, the final report reflected the main efforts of the project. The major empirical studies carried out in the project were:

Study 1: Team leadership in trauma – an observational and interview study. This study was conducted to answer the broad questions of how leadership was defined in the context of trauma teams. We spent over 225 hours at observing the treatment of approximately 175 different patients. We interviewed 10 providers from different positions (attending surgeon, attending anesthesiologist, surgical resident, emergency medical resident, medical student, nurse, and trauma technician).

Study 2: A review of archival, videotaped team performance. We analyzed 120 video taped team performance to extract leadership scenarios encountered by trauma teams.

Study 3: A survey study of leadership behaviors. We developed a 59-item survey of leader behavior and collected the surveys from 35 members of trauma care providers. The survey was to identify key leader behaviors.

Study 4: A field experiment manipulating leader location. This research was the key to the project. We instituted a research paradigm in a real patient care setting: Level-I trauma care to understand distant leadership. A battery of measurement tools was deployed in 127 patient care cases with 89 study participants (care providers involved in the study). Of the 127 cases, 59 were videotaped. Among the videotaped cases, 22 were in distant leadership conditions. We performed a range of analyses from time-accuracy measurement of performance, to intra-team communication measures, to case analysis of 152 team performance segments.

Study 5. In-depth interview study: we interviewed 16 surgeons to understand leadership identification from the point of view of attending surgeons and residents. We gained insights into important topics of team effectiveness, leader identity, and leader functions. Based on the interviews, we developed the concept of team leadership systems to take into account the dynamic flow of leadership.

Throughout the project, we published 11 peer reviewed proceeding articles and book chapters and made presentations in conferences of professional associations such as Academy of Management, Society of Industrial and Organizational Psychology, and Human Factors and Ergonomics Society.

The theoretic and conceptual efforts (specific aims a-c) will be based on existing literature on team performance and on the analysis of an existing video library of team performance collected in a stressful environment. The cases from the video library will be reviewed to extract segments representative of effective and ineffective occurrences of leadership. These segments will be used as the basis for the leadership matrix, model, and measures. Prospective empirical efforts (specific aim d) will utilize an already established study environment in a Level-I trauma center. Comprehensive audio-video recordings will be the primary data collection method. Two modes of communication will be randomly assigned in consecutive cases. Leadership effectiveness will be measured by both team performance (speed and accuracy) and process parameters (decision processes and leadership control processes). These dependent measures will be analyzed in relationship with several independent variables including risk, urgency, uncertainty, task structure, and workload.

### **Final Summary**

Our research depicted a dynamic, fluid team leadership in achieving two commonly found goals of teams: performing and training. Teams adapt their leadership depending on task conditions, team experience, and leader location (in the case of distant leadership). We proposed the concepts of team structures and team leadership systems to provide both practical guidance to team leadership and a theoretical basis for future team leadership research.

# **Leadership, Team Processes, and Team Adaptation: The Development and Influence of Functional Leadership Capabilities on Team Adaptability to Adversity**

**Contract #:** DASW01-98-K-0005  
**Institution:** George Mason University

**Contract Dates:** 8/1/98-7/31/03  
**PI:** Stephen J. Zaccaro  
**Co-PI:** Richard Klimoski

## **Research Summary**

The purposes of this research program are (a) to examine in detail the influences leaders have on team processes contributing to team adaptation, (b) to examine training and development principles that contribute to the development of adaptive military leaders and teams; and (c) to develop and examine the psychometric properties of a leader assessment tool that measures personal qualities contributing to adaptation. Our laboratory research examines (a) leader attributes that promote leader and team adaptation, and (b) training feedback characteristics that foster team adaptation. Our field studies are designed to (a) validate an assessment battery constructed to measure multiple leader attributes related to leader flexibility, (b) examine work experiences related to the development and emergence of attributes promoting leader flexibility, and (c) test training principles regarding the development of leader flexibility and (d) develop a leader adaptability training program.

## **Contributions to Basic Research**

The current work advances basic research in the areas of leader and team adaptability and leader development. One product of this effort is a comprehensive conceptual framework that describes a career-long process of leader development. This framework builds on previous research in the literature and incorporates multiple sources of developmental experiences (i.e., formal training, self-development, work assignments, mentoring, coaching, feedback). Also, our research provides support for training principles designed to grow adaptability skills in both leaders and team members. Our work also identifies key leader and team attributes that promote adaptability and training interventions that can be used to develop these attributes. Based on these training principles and interventions, we have developed a comprehensive leader adaptability training program that was administered at the Army War College. Finally, we have a growing database of research that provides support for proposed relationships between certain key leader attributes and adaptability.

## **Potential Army/Military Applications**

The applications of this research for the Army are expected to be in the areas of training assessment and curriculum. The assessment battery measuring leader flexibility can serve as a very effective training diagnostic tool in multiple Army training settings. The assessment battery will identify leader strengths and weaknesses on various leader adaptability skills and attributes and provide trainers with insight into which areas that should be targeted in training. Further, the field studies yield specific guidelines and curriculum tools that target the development of leader flexibility. These guidelines and tools are expected to be constructed in accordance with the different developmental needs that emerge at various points in an officer's career. Also, the

adaptability-training program that was administered at the Army War College should have direct applicability to the development of adaptive senior leaders.

### **Accomplishments**

We have completed five experimental studies. Our first study examined the effects of process versus outcome feedback, and individual versus team-level feedback on team adaptation. We also examined the role of certain leader adaptability attributes on team processes and performance. Our findings indicated that team-level, process oriented feedback, such as feedback about the team's quality of communication, coordination, strategy, rather than feedback regarding outcomes, produced the strongest adaptive responses in teams. However, leader and team metacognitive skills moderated the influences of feedback on team adaptability. In our second study, we investigated other dimensions of training feedback, including public versus private feedback, on team efficacy and team mental models, as well as team adaptation. Our findings indicated that shared mental models mediated the effects of feedback parameters on team adaptability. In our third study, we examined the role of task variability and feedback in training performance scenarios on adaptability. Our findings were mixed, but overall they indicated that process-oriented feedback during training increased adaptability in team performance, but varying a team's task during training did not enhance adaptability in team performance. The findings for variability were contrary to expectations and further work is being done to explore possible explanations (e.g., increasing the amount of task variability). Our fifth study examined the effects of variability in greater detail and found that the combination of variability and feedback produced the strongest effects on team adaptability. In our fifth study, we explored in more detail the nature of team mental models, finding that some mental models were idiosyncratic to the team, while others derived from common experiences of group members.

For the field research, we have developed conceptual models that describe the influences of work experiences, formal instruction, mentoring and coaching processes, feedback systems, and self-development experiences on individual attributes related to leader flexibility. We have also developed an assessment battery that measures cognitive, behavioral, and dispositional attributes linked to leader flexibility. We have completed several validation studies, affirming the psychometric strengths of this battery. We also examined the influence of these attributes on the relationship between reported developmental work experiences and gains in tacit knowledge in military officers. We have administered this battery to several classes at the Army War College (AWC) and to a sample of managers and executives in several private corporations. We found the influences of developmental work experiences on leader tacit knowledge depended upon the levels of metacognitive skill, cognitive complexity, and tolerance for ambiguity displayed by the leader. Finally, we have administered the battery at the the Center for Creative Leadership and the Air Command and Staff College, and collected ratings of adaptability in leadership simulations. We found that certain combinations of cognitive, social, and dispositional attributes were the strongest predictors of leader adaptability, providing support for the idea that one should look at patterns of attributes to predict leader adaptability. We found similar results in data collected at the AWC.

In related funded efforts, we have developed and pilot-tested a proposed training curriculum at the AWC. This program applies principles of adaptability training that were derived from the conceptual models developed in year one of this effort. We have implemented

full versions of this course at AWC in Spring, 2001 and at ICAF in Fall, 2002. These applications of our research did not allow for a training evaluation. We are currently exploring other venues for such evaluations. We also revised components of this training for use in a adaptive leader training program being developed by Personnel Decisions Research Institute (PDRI).

### **Final Summary**

Taken together, our findings provide insight into training strategies, particularly the delivery and content of training feedback and the structuring of training scenarios in performance exercises, that foster leader and team adaptability. We have also identified team and leader attributes that can influence how training design parameters influence training outcomes. We have identified and validated sets of cognitive, social, and dispositional attributes that predict leader effectiveness in dynamic and complex operating environments. We have also demonstrated that some of these attributes moderate how developmental experiences influence some learning outcomes. These findings add to the literature on adaptive leadership, leader training and development, and the prediction of leader effectiveness, particularly in military settings. This research has provided prototypes for a number of assessment tools that have begun to be adapted for use in particular military contexts.

### **Link to Applied Research**

This research links to Dr. Halpin's two applied programs, "Leadership: Developing Leaders in a Changing Army" (FY03) and "Tomorrow's LEADERS: Leading the Objective Force" (FY04) programs.

The goals of the first applied program, "Developing Leaders in a Changing Army," and the goals of the basic research align. Both focus on leader adaptability and both involve developing leader assessment and self-development systems incorporating cognitive and interpersonal leadership skills. Hence, work from the basic program could be directly applicable to the work being completed in the applied program. For example, one goal of the applied research program in leader development is to devise an empirically valid method that embeds experience in a self-development system for fast-tracking Army leadership tacit knowledge in Lieutenants and Captains. Our work offers training principles and tools for embedding leader adaptability development that could be incorporated in the self-development system.

The second applied program, "Tomorrow's LEADERS: Leading the Objective Force," is linked to the basic research efforts in developing adaptive/flexible leaders. The basic research involves testing training principles for leader adaptability that include leadership assessment and self-development, and incorporates cognitive and interpersonal skills as well as individual dispositions. Hence, this links directly to the applied program's goal of developing recommendations for an integrated leadership assessment and self-development system for officers, incorporating both cognitive and interpersonal skills. The work in the basic program could be employed in the applied program's assessment and self-development system.

### **BRO RESEARCH OBJECTIVE #3:**

*Provide fundamental knowledge for identifying and measuring the attributes and skills that are critical to soldier recruiting, performance, and retention in the transforming Army.*

Research in this section is directed toward identifying and measuring the aptitudes and skills that are unique to the human performance requirements of the Future Force. Exploring the sociological and psychological factors that could influence recruitment, retention, and Army performance are important aspects of this research objective.



## **The Interactive Effect of Feedback-Sign and Regulatory Focus on Performance of Creative Task Versus Error-Detection Task**

**Contract #:** DASW01-02-K-70512

**Institution:** The Hebrew University of Jerusalem

**Contract Dates:** 11/4/02-11/3/03

**PI:** Avraham N. Kluger

**Co-PI:** Dina Van-Dijk & Miriam Erez

### **Research Summary**

Consider the following question: Does positive (negative) feedback encourage or discourage performance? This seemingly simple question defied simple answers. A comprehensive meta-analysis showed that positive feedback had a positive effect on performance in some studies, while in other cases it had no effect, or a negative effect, and vice versa for negative feedback (Kluger & DeNisi, 1996). To account for these variable feedback-sign (positive or negative) effects, Van-Dijk and Kluger (in press) suggested applying self-regulation theory (Higgins, 1997, 1998). This theory distinguishes between promotion and prevention focus of motivation. Van-Dijk and Kluger suggested that relatively high levels of motivation are induced either by failure under prevention focus (failure to meet obligations) or by success under promotion focus (fulfilling a desire). Thus, the theoretical answer to the question - does feedback encourage performance - is it depends. It depends on whether the person is eager to perform the task or is obliged to do so.

In initial experiments testing this explanation, Van-Dijk and Kluger found that people with a prevention focus are more highly motivated by negative feedback while those with a promotion focus are motivated by positive feedback. However, the Van-Dijk and Kluger studies (in press) were preliminary in nature. They used hypothetical scenarios to gauge motivation, but had no performance measures. In addition, they did not consider the task characteristics which could be a decisive factor in inducing either promotion or prevention focus. Thus, the goal of this project was to test whether the interaction of feedback sign with regulatory focus affects actual performance, and whether the nature of the task influences the situational regulatory focus - promotion versus prevention. Specifically, our research examines the effect of feedback sign on the performance of a task considered to induce situational promotion focus (creativity task) and on the performance of a task considered to induce situational prevention focus (error-detection task). Briefly, it was expected that negative feedback will improve the performance on error-detection tasks, and positive feedback will improve the performance on creative tasks. Yet, this interaction was expected to further depend on individual differences in self-regulation foci: the benefit of positive feedback for the performance of creative tasks was expected only among participants with a chronic-promotion focus.

### **Contributions to Basic Research**

This project provides an explanation for the complex effect that feedback sign is likely to have on motivation and hence on performance. It points out an interesting phenomena related to negative feedback. This project's hypothesis suggests that under prevention focus negative, but not positive, feedback would best enhance performance. Yet, vast literature has documented the debilitating effect of negative feedback on self-efficacy and as a result on performance. Specifically, existing theories concentrate on the mechanism of expectation for future

performance as a key for understanding feedback-sign effect. Our work shows that expectation is only part of the story where value or desirability is another part. That is, failure can not only reduce expectations for success, it can also increase the desirability of future success. Thus, our work may pave the way to identify means to reap the motivational benefits of negative feedback while avoiding the traps of debilitation associated with failure.

### **Potential Army/Military Applications**

Our hypotheses suggest that no feedback system can fit all. That is, certain military occupations that largely require high vigilance may be best staffed with soldiers who have a strong chronic prevention focus (which may be measured by values, vocational interests, and perhaps with personality traits such as conscientiousness). Such occupations may include monitors of radar screens, guards, maintenance personnel, etc. These soldiers' performance may benefit most from training that emphasizes punishment for poor performance, and from a performance appraisal system that emphasizes error-free performance, which prevents the promotions of soldiers with records of frequent errors and disciplinary records. In contrast, other military occupations that requires a state of eagerness, for example among elite fighting units, may be best staffed with soldiers that have a strong chronic promotion focus, and their training and evaluations may benefit most from awards, prizes and recognition of excellence.

The application of our recommendation would be relatively easy to implement. The manipulation of veridical feedback so it is perceived either as negative or positive can be achieved with framing: messages can be easily framed by emphasizing either the half-full glass or the half-empty glass (Levin, Schneider, & Gaeth, 1998). This was already found, but not explained theoretically, by Wade (1974). He instructed people to monitor either errors versus or successes in a vigilance task and found that monitoring errors produced better performance. Using this ease of manipulation, we recommend emphasizing the negative aspects of performance when the behavior in question is about prevention. For example, a tank maintenance task should be monitored by the number of problems found in the inspection of the tank, and not by the number of problem-free tanks successfully maintained. In contrast, when monitoring training of officer cadets being instructed in suggesting a battle plans, performance should monitor the number of excellent ideas generated by the trainees rather than monitoring the number of poor ideas. Of course, in many military occupations one needs both prevention and promotion abilities. Under these circumstances a complex schedule of feedback sign will be needed. Yet, commanders can be trained to decode the situations that are more likley to benefit from praise versus criticism. The practical rule that emerges from our theory is "punish failure to prevent errors, but do not praise error detections; praise success in creative tasks, but do not punish poor performance on these tasks".

### **Accomplishments**

Our experiment corroborated our hypotheses. Prior to the experiment, all participants filled out a value questionnaire that was used to assess their chronic self-regulatory focus. In the experiment, half of the participants worked on an error-detection task (finding errors in arithmetic calculations) and the other half worked on a creativity task (designing an advertisement using PowerPoint software). After working on the task, participants were provided with a bogus feedback indicating that so far they were performing either well or poorly.

After receiving feedback, participants were asked to continue working on their task. Our key interest was in the effect of feedback sign on post-feedback performance change.

As expected, the effect of feedback sign depended both on the nature of the task and on the values (chronic self-regulatory focus) of the participants. Specifically, (a) in the error-detection task performance was higher after negative feedback than after positive feedback, whereas, in the creative task, performance was higher after positive feedback than after negative feedback; (b) for participants low in chronic-promotion focus, performance was higher after negative feedback than after positive feedback, whereas, for people high in chronic-promotion focus performance was higher after positive feedback than after negative feedback; and (c) people low in chronic-promotion focus were more likely to show improved performance after failure than after success, regardless of the task. In contrast, the reactions of participants high in chronic-promotion focus to feedback-sign depended on the task: they improved performance after failure on the error-detection task and after success on the creativity task.

### **Final Summary**

The results of our experiment further corroborated the theory advanced by Van-Dijk and Kluger. These results enable us to predict that positive feedback would be more effective for people with a promotion focus, whereas negative feedback would be more effective for people with a prevention focus. Furthermore, our experiment suggests that promotion focus versus prevention focus could be determined by individual differences (we measured by values) and by the nature of the task (we manipulated error-detection tasks versus creativity task). Our findings suggest that no feedback system can fit all. That is, organizations, including the military, should maintain congruency between feedback system, task type and employees characteristics. Specifically, organizations (or certain units within organizations) that largely require high vigilance such as certain military jobs (e.g., radar operator), security companies, and banks, may be best staffed with employees that have strong chronic prevention focus, because these jobs usually emphasize the negative outcome of errors and mistakes. Performance of prevention-focused employees may benefit most from training that emphasize avoiding poor performance, and by performance appraisal systems that emphasize error-free performance, which can prevent the promotions of employees with records of frequent errors and disciplinary records. In contrast, other organizations that require a state of eagerness, for example, intelligence units, and commando units, may be best staffed with employees (officers) that have a strong chronic promotion focus. Performance of promotion-focused employees may benefit most from awards, prizes and recognition of excellence. Finally, our project calls for understanding the interplay between feedback sign and promotion and prevention in complex tasks that may require the ability to shift from promotion to prevention. For example, the performance of an excellent soldier in a commando unit may require both the ability to prevent trouble and the creativity needed to improvise performance in the field. Thus, the conclusions that can be drawn from our project is that feedback (whether positive or negative) should be tailored for the person/task combination and that the combination for person/task in terms for promotion and prevention requires further theoretical and empirical work – a path that was opened by the current project.

## Personnel Turnover and Team Performance

**Contract #:** DASW01-00-K-0018

**Institutions:** University of Pittsburgh  
and Carnegie Mellon University

**Contract Dates:** 9/1/00-11/30/03

**PI:** John Levine

**Co-PIs:** Linda Argote, Kathleen Carley,  
& Richard Moreland

### Research Summary

One of the most daunting challenges for work teams is *personnel turnover* (i.e., exit of current members and/or entry of new members). Turnover can have profound consequences for team performance, because it alters both the knowledge distribution in the team and the relations among team members. When current members leave, those who remain must renegotiate their responsibilities for storing and sharing information. When new members enter, they must acquire knowledge about their roles and about others' competencies and responsibilities. In some cases (e.g., when the team is performing poorly and newcomers possess task knowledge), newcomers can introduce changes in team behavior and thereby enhance team adaptability.

This research program utilizes two team tasks (decision making and production) and employs two methodologies (laboratory experimentation and computer simulation). Three related lines of work are being conducted. Studies using the experimental version of the decision-making task investigate the conditions under which newcomers stimulate adaptation and innovation in work teams. Studies using the experimental version of the production task investigate how newcomers affect the team's transactive memory system -- a shared mental model about how task competencies are distributed across team members. The simulation studies, which employ powerful computer programs that have proven useful in modeling group and organizational performance, extend the laboratory work in various ways. For example the simulation work extends the laboratory research by investigating the impact of turnover in larger social units and over longer time periods.

### Contributions to Basic Science

Only a handful of studies have examined personnel turnover in teams. These studies suggest that turnover typically disrupts team performance, but is more deleterious under some conditions than others. Because these studies vary widely on conceptual as well as methodological grounds, their results are difficult to integrate in a theoretically satisfying manner. Therefore, a major goal of the present research program is to provide a stronger theoretical framework for understanding the consequences of turnover (positive as well as negative) for work teams. One product of our work is a comprehensive theoretical framework for understanding the conditions under which newcomers can alter the work practices of teams they enter. In addition, our simulation work makes important headway in integrating knowledge about turnover in groups and organizations, as well as suggesting a number of interesting hypotheses for investigation in both laboratory and natural groups. Finally, we have obtained a substantial corpus of laboratory and simulation data that enrich the literature on how teams adapt to the challenge of personnel turnover.

## Potential Army/Military Applications

Personnel turnover, a fact of life in the Army, can have several consequences. For example, when membership change is planned and new personnel are well-trained, turnover may have minimal effects on team performance. In contrast, when membership change is unplanned and/or new personnel are not prepared for their mission, turnover may severely degrade team performance. Finally, when team performance is already low (e.g., because well-learned task routines are not suited to a new operational environment), turnover may significantly enhance team performance. Our work suggests several strategies for reducing the costs and enhancing the benefits of membership change in teams. For example, our research on transactive memory systems suggests that warning teams that turnover will occur, combined with information about a newcomer's skills, partially mitigates the negative consequences of turnover. Our work on newcomer innovation suggests that allowing teams to choose their task strategy reduces their willingness to adopt new strategies in the face of failure. And our simulation studies suggest how turnover might be used to destabilize "enemy" groups, which is relevant to counter-terrorism situations.

## Accomplishments

In our laboratory work on newcomer-induced innovation, we used an air-surveillance task in which three-person teams (a commander and two specialists) monitored planes flying through a simulated airspace. The first study, using existing data, assessed the impact of newcomer ability and status on team performance and strategy-relevant communication. Teams that had worked on the task either experienced turnover (involving a new commander or specialist from another team) or did not. As predicted, turnover did not substantially influence team performance, presumably because the team task was highly routinized and newcomers were experienced. Also as predicted, high-status, high-ability newcomers improved team performance more than did other newcomers, and newcomer entry stimulated strategy-relevant communication, a potentially important mechanism of newcomer influence. Our first study directly investigating newcomer innovation manipulated whether the team (a) chose or was assigned its initial task strategy and (b) failed or succeeded when using this strategy prior to the newcomer's entry. After performance feedback, a confederate replaced one subordinate. The confederate suggested a new strategy for the next work shift. As predicted, the newcomer produced more innovation when teams did not choose their strategy and subsequently performed poorly. Our second innovation study, still in progress, is testing the hypothesis that subordinate newcomers who behave assertively will produce more innovation than nonassertive newcomers following team failure, but not team success.

We also conducted two laboratory experiments investigating how turnover affects teams' transactive memory systems, using a task in which teams assembled transistor radios. In the first study, some teams were warned, prior to group training, that turnover would occur at the start of team testing, whereas other teams were not warned. In addition, some teams in each warning condition later experienced turnover (replacement of a current member by a newcomer who had been trained alone), whereas others did not. We expected stronger transactive memory and better team performance when turnover did not occur than when it did, whether or not a warning was given. When turnover occurred, we expected the presence vs. absence of warning would differentially affect transactive memory and performance. Results did not support our hypotheses, apparently because newcomers tried hard to learn the task, perhaps to impress

oldtimers, and oldtimers worked hard after newcomer entry, perhaps to impress newcomers. In the second study, after group training, teams experienced one of the following: no turnover, turnover without warning, or turnover with warning. In the latter case, only oldtimers (people who remained after turnover), only the newcomer, or both oldtimers and the newcomer received information about the newcomer's skills. Preliminary results suggest that, as expected, no turnover teams performed better than turnover teams with warning (and information about the newcomer), which in turn performed better than turnover teams without warning.

In addition, we developed computational models for simulating group performance in both the newcomer innovation and transactive memory (TM) domains and ran virtual experiments to validate and extend the models against laboratory and field data. We found, for example, that TM is most valuable in groups of 16-30 members and in volatile task environments. In addition, we examined how IT affects the development of TM and mitigates the effects of turnover, finding, for example, that referential databases can substitute for human TM and that IT can facilitate handover when newcomers enter a group. We also developed metrics for identifying critical individuals in networks, focusing on agents' relations to others and knowledge (degree of centrality, access to information, ability to direct others) and their privileged position (exclusivity in task or knowledge). Finally, we ran virtual experiments on network healing, examining the implications of removing various kinds of agents (e.g., people in specialized positions, newcomers). Results indicate that the underlying network structure controls the network's ability to recover, the speed of recovery, and relative impact of removing different types of agents.

Finally, we wrote several theoretical and review papers on topics related to personnel turnover, including newcomer innovation in work teams, group reactions to loyalty and disloyalty, scientific collaboration, role transitions, and group composition.

### **Final Summary**

Our research has identified several factors that influence the impact of personnel turnover on team performance. In addition, it has provided information about the conditions under which newcomers can influence existing work practices in teams. These findings add to the literatures on team performance, newcomer innovation, and transactive memory. They also demonstrate the synergies that can result when investigators from different disciplines (social psychology and sociology) use different methodologies (laboratory research and computer simulation) to examine common problems.

## **Enlistment Properties of University Students**

**Contract #:** 1435-01-01-CT-31151  
**Institution:** Northwestern University

**Contract Dates:** 6/1/01-5/31/04  
**PI:** Charles Moskos

### **Research Summary**

Heretofore Army enlistment incentives have largely focused on the recent high school graduate. The college graduate has never been viewed as major source of enlistees. This research was the first ever to survey undergraduates on campus on enlistment propensities. Surveys were conducted at a cross-section of universities: Northwestern University (selective private university), University of Arizona (major state university), University of California-Los Angeles (major state university), and University of Illinois-Chicago (predominantly working-class students). Over 1,700 undergraduates completed surveys at these four universities. The surveys were conducted during the academic years 2000-01 and 2002-03.

Surprisingly, the differences in enlistment propensity between the universities were remarkably similar despite the variation in the socio-economic background of the four universities. The core finding was that there is a definite, albeit limited, undergraduate population that would be amenable to a short enlistment option -- 18 months -- coupled with educational benefits. Enlistment propensity was positively correlated with having a friend/relative with military experience, student debt, and the probability of serving overseas.

It is noteworthy to mention that enlistment propensity was not correlated with either political orientation or knowledge of military life. The only major sociological difference was that men were about twice more likely to show an enlistment propensity than women, although the women were three times more likely than the men to show an enlistment propensity for civilian national service.

### **Contributions to Basic Science**

The findings support a dual-market approach in recruitment. This contrasts with the prevailing labor-market paradigm that dominates the research of Department of Defense contract consultants. Recruitment policies must incorporate social psychological theories. In particular, the surveys show that length of enlistment term is more of a factor than monetary incentives among college undergraduates.

The data also indicate that models of recruitment that rely only on econometric analyses are deficient. It is time to introduce social psychological variables in recruitment analyses. The eminent psychologist Leon Festinger developed a "comparison theory" in the 1950's. This is to say that humans evaluate themselves not so much by objective standards such as monetary rewards, but by comparisons with people around them. Likewise, the noted social psychologist James Coleman rejected the economist's "individualistic premises" and argued for the importance of relations among people in making life choices.

Similarly, the concept of "reference groups" would enlighten recruitment studies. This is to say that people get their cues from meaningful groups rather than a generalized other. For recruitment purposes, nothing would be more meaningful than one's friends joining the Army.

### **Potential Army/Military Applications**

The basic finding is that for college graduates, shorter enlistments are more favorable. Some 35 percent of the surveyed students expressed a favorable enlistment propensity for an 18-month enlistment coupled with educational benefits that would reduce student loans.

A significant finding is the high percentage of college graduates who now plan go on to graduate school. Forty percent of the surveyed students indicated such intentions right after graduation. In point of fact, a higher percentage of youth now go on to graduate school than went to undergraduate school in the immediate post-WWII years. These new realities argue for a rethinking of GI Bill-type programs to include appealing to future graduate students.

From this standpoint, a break between a bachelor's degree and graduate studies might be a new incentive for military recruitment. For college youth, the citizen-soldier rather than a military career is where recruitment appeals must focus. For this population, the emphasis should be placed on military service as a rewarding change of pace and interim experience between undergraduate and graduate school or between school and career.

Other applications of the research for Army enlistment include: (1) rely more on veterans who were not career soldiers for recruiters, (2) aim advertisements at veterans to influence younger relative and friends to enlist, (3) consider having university newspaper editors visit troops in the field and do follow-up stories.

### **Accomplishments**

Starting this fall, the Army will introduce a modified form of the 18-month enlistment option. In some degree, the enabling legislation specifying this option was influenced by the research reported herein.

### **Future Plans**

Follow-up surveys will be conducted at selected university campuses. As always, the principal investigator will conduct research on sociological topics requested by senior military officers and Defense Department officials.

# **Comprehension and Memory of Spatial and Temporal Event Components**

**Contract #:** DASW01-02-K-0003

**Institution:** University of Notre Dame

**Contract Dates:** 05/01/02-04/04/04

**PI:** Gabriel A. Radvansky

## **Research Summary**

When people are presented with information about events in the world, in order to successfully comprehend and remember that information, they need to be able to deal with changes that occur. That is, situations and events are constantly and dynamically changing over time. As such, people must be able to identify when the changes that have occurred, and to update their understanding of the event in a way that takes these changes into account. There are many components of a situation that can dynamically change. The focus of this project is on changes in spatial and temporal information about an event. That is, when there has been a shift in space (an entity is in a new location) or time (a significant period of time has passed), people need to know what information from the previous situation will still be relevant and what information is not. For example, if a person learns that someone has traveled from New York to London, after noticing that this change has occurred, in order to properly understand the situation the person should mentally keep track of the fact that the traveler had brought a computer disk with classified information with her, and that she has left behind her book of contacts. We are making this assessment of spatial and temporal updating using our understanding of how people create and manipulate their understanding and memory of the world by using mental representations called mental models. By looking at the success that people are able to track and update this information we hope to be able to better identify not only those circumstances where people are able to do this correctly, but also, more importantly, those circumstance where people are not successful at updating this information, and ways to correct that deficiency.

## **Contributions To Basic Science**

This project will provide us with a more advanced understanding of how people track changes in descriptions of situations that occur in the world. This research follows several recent developments in mental model theories and extends them by looking more precisely and the stages that are involved in updating understanding. This more precise analysis will allow for a clearer understanding of how people comprehend, monitor and remember changes in events and situations in the world based on the information they receive. From this data, we hope to develop a means of identifying when people are having trouble updating event information, and provide a more targeted means of correcting those problems.

## **Potential Army / Military Applications**

The potential applications of this research for the Army are in the areas of training and system interfaces. In the area of training, this research will provide insight into the specific difficulties that people have updating their understanding of events. Knowing in what ways people have trouble tracking changes in space and time will allow for the development of procedures that would directly target such deficits. In addition, because the modern soldier needs to interact with sophisticated technologies that involve tracking various entities through time and space (whether they be enemy forces, one's own supplies or friendly forces), knowing the

capabilities and limits of human event comprehension and memory will help in the design of these systems. Spatial and temporal information that is readily tracked by people would need either minimal or no feedback from the system. However, those aspects of spatial and temporal processing that are more difficult would be a higher priority for that system, in terms of augmenting the soldier's current capabilities.

### **Accomplishments**

We have completed data collection looking at people's ability to process spatial shifts. That is, when people are comprehending information and a shift in space occurs, as when a person moves from one location to another, how well are people able to process this information, and how are the different abilities related to one another? We have looked at a number of measures that assess spatial processing. The first is the ability to detect that a change has occurred. The second is to establish a representation of the new location. The third is to be able to keep activated information from the previous location that will be relevant in the new location. (e.g., if a person brought an object to the new location, knowledge of this object should continue to be available). The fourth and final one is to be able to remove from the current stream of thought any knowledge about entities that were present in the initial location, but are not in the new location. These spatial processes were measured using a number of dependent variables to converge on a coherent picture of the updating process.

The results of this work have demonstrated that overall people show the sorts of effects that one would expect. They effectively process information about new locations, knowledge about entities that are moved to the new location continue to stay available, whereas knowledge about entities that are part of the prior location become less available. Moreover, the ability to successfully update one's understanding of the event in one area is related to the ability to update in other ways. Currently we are further exploring in these data how these spatial updating processes are related to more general cognitive measures that were collected during the study, including working memory span, processing speed, and general reasoning.

### **Future Directions**

Currently we are following two lines of experimental inquiry. The first is that we are beginning to explore the ability of people to update temporal information about a situation. This will parallel our efforts looking at the ability to update spatial information. That is, we will be looking at people's abilities to detect temporal shifts, to create a new temporal framework for when such shifts occur, to maintain information that continues to be relevant after a temporal shift has occurred, and finally, to remove information from the current stream of thought that is no longer relevant because of the temporal shift. The other line will continue looking at the ability to process spatial shifts. However, rather than relying on strictly language-based materials, we will have people traveling through desktop virtual reality environments. The aim of this line of research will be to look at how discoveries in language-based understand of situations and events can be extended to more realistic situations. The desktop virtual reality environment is helpful because it allows us to construct various aspects of a spatial environment to adequately test their influence on thought.

## **Working Memory Influences on Long-Term Memory and Comprehension**

**Contract #:** DASW01-99-K-0001  
**Institution:** University of Notre Dame

**Contract Dates:** 06/15/99-06/14/02  
**PI:** Gabriel A. Radvansky

### **Research Summary**

The purpose of this research program was to look at the role of working memory abilities in the comprehension and memory of events and situations. Complex sets of information about events in the world need to be readily understood by the people entrusted with that information. This includes the ability to understand descriptions of events occurring in some other part of the world, or the need to understand and accurately remember instructions about how to perform (what to do) under various circumstances when the need arises. To understand information well, a person must be able to successfully comprehend the nature of the events that are being referred to by the descriptions that have been provided. The simple retention of a collection of individual pieces of information is insufficient. A person must be able to properly relate that information to external circumstances. The primary goal of this project was to assess how an individual's cognitive abilities can be used to predict future performance on comprehension and long-term memory tasks. Specifically, this project focuses on how working memory (that portion of cognition where information is actively manipulated) influences higher-level comprehension and the long-term memories that result from this comprehension. These long-term memories are often called mental models because they are mental simulations of a set of circumstances that could exist in the world. This project assessed the degree to which the successful processing of mental models is predicted by traditional measures of cognitive ability, or whether this processing can be better predicted by measures aimed more directly at how these representations are created and retrieved. Several studies were conducted that looked at various ability tests that can be used to predict future performance in processing event and situation information. This is important because our knowledge about events in the world relies more on the mental models we create than on lower level representations, such as propositional codes. Mental models are a means of capturing and coordinating complex sets of information about circumstances and events.

### **Contributions To Basic Science**

This project provides us with a more advanced understanding of working memory capacity and processes as well as the role these play in the various aspects of comprehension and long-term memory of complex sets of information about events in the world. This research follows and integrates long-time traditions in each of these areas of cognition. Furthermore, a better understanding will be gained of how people comprehend, monitor and remember changes in events and situations in the world based on the information they receive. Lastly, we are developing a computer model of event comprehension and memory that will allow for a much more specific prediction of a given individual's performance.

## Potential Army/Military Applications

The potential applications of this research for the Army are in the areas of training assessment and curriculum. An assessment battery measuring complex information comprehension and memory may be used to identify individuals who are better able to process complex information and potentially, to identify individuals' areas of weakness. These assessment tools, coupled with targeted training, can serve to minimize the amount of time needed to increase a person's ability to comprehend and remember event information.

## Accomplishments

We have completed data collection exploring the accuracy of traditional measures of working memory abilities and their prediction of performance on various established mental model measures. This study showed that while these measures do predict a few aspects of performance, there are many aspects of comprehension and memory that are unrelated to them. Thus, they are limited in their ability to predict future performance. In many cases, other measures of complex event processing were better at predicting future performance. The data from these studies has been broken down into four papers. One has been published in the journal *Memory & Cognition* where it was the lead article, one is under review at the *Quarterly Journal of Experimental Psychology*, and one is in press at the *American Journal of Psychology*. The fourth manuscript is in preparation and will soon be submitted to the *Journal of Experimental Psychology: Learning, Memory and Cognition*.

Additionally, we are continuing to develop a computer simulation of mental model construction and use. To constrain its initial development, we have limited the model to solving categorical logic problems. To date, the computer model has been successful in predicting the accuracy and response time of people's ability to understand a description of a state of affairs in the world and in drawing the appropriate inferences from that information. We will continue to expand this model to contain other sorts of events knowledge. This model is a very exciting aspect of the project because it has the potential to identify, with a high degree of precision, the specific nature of the difficulty people have in constructing mental models and making inferences based on their understanding of the world.

## Final Summary

From this research, there are a number of key findings. First, traditional measures of working memory span, such as the word span sentence span, operation span, and spatial span tests, are good predictors of a person's ability to remember individual pieces of information. That is, the ability to remember individual facts. However, these measures are unrelated to a person's ability to comprehend and remember various components of a situation. These working memory span measures only influence event comprehension and memory at the mental model level to the extent that thinking at that level depends on individual facts. If a person can go beyond this, then their performance is unrelated to working memory capacity. The situation-based processes that were found to be unrelated to working memory span include the updating of event knowledge, the management of situation information retrieval, the detection of situational inconsistencies, and the integration of multiple pieces of information that refer to a common situation. While there was little to no relation between working memory span and event cognition performance, some of the situation-based cognitive measures were related to one another. However, because

understanding events and situations involves a complex of many different types of information and mental processes, the inter-relation of these components was limited.

# **Development and Empirical Evaluation of a Theory of Socially Intelligent Job Performance for United States Army Junior and Non-Commissioned Officers<sup>1</sup>**

**Contract #:** DASW01-02-K-0002

**Contract Dates:** 5/01/02-10/15/03

**Institution:** Personnel Decisions Research Institutes, Inc. **PI:** Robert J. Schneider

## **Research Summary**

The purpose of this research program is to enhance understanding of the nature of socially competent performance in junior commissioned military officers. This involves (1) determining the various dimensions of socially competent performance; (2) identifying the attributes that predict those social performance dimensions, both directly and indirectly through other attributes; and (3) formulating a theory of how various attributes (intelligence, socially-oriented personality characteristics, social intelligence, social motivation, and social knowledge) relate to social performance, and to each other. A by-product of this research will be increased understanding of the nature of social knowledge and social motivation. Of particular interest is whether social knowledge and social motivation each consist of one or multiple dimensions and, if they consist of multiple dimensions, determining the nature of those dimensions. We are carrying out this research because of the increasing importance of social competence to the Army's ability to carry out its missions. For example, an officer's social competence helps determine his or her ability to foster unit cohesion, mentor soldiers, work effectively with individuals ranging widely in personality and work style, lead effectively when deployed to foreign countries, and handle new roles (e.g., promotions) effectively.

## **Contributions to Basic Research**

This research advances ongoing theoretical work by a number of researchers on the nature and predictors of effective job performance. It does so by (1) focusing in on the major dimensions of *social* job performance; (2) determining the dimensions of social knowledge and social motivation, attributes believed to directly influence effective social job performance; and (3) formulating and testing separate theories (all with the same general form) of the attributes that predict each major dimension of social job performance. Our research will also provide additional insight into the relationship between intelligence and social abilities, a research topic that has been of keen interest to researchers since the 1920s, when social intelligence was first researched, and which remains of interest today.

Another important scientific contribution of this research involves the manner in which social knowledge is measured. The social knowledge test (SKT) used in this research involves a series of video-based social scenarios in which actors portray socially effective and socially ineffective behaviors. People's social knowledge scores are based on the number of targeted effective and ineffective social behaviors they are able to identify correctly (including reasons

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<sup>1</sup> We had initially hoped to utilize actual Army junior commissioned officers and NCOs as subject matter experts and examinees in this research. However, it was not possible to gain access to these types of individuals in a way that was consistent with our research needs. We therefore made use of advanced (3<sup>rd</sup> and 4<sup>th</sup> year) ROTC cadets and midshipmen. Since ROTC cadets and midshipmen are in training to become junior commissioned officers, and not NCOs, they were not in a position to speak to the requirements of NCO positions. The population to which our project will be generalized was therefore necessarily changed to junior commissioned officers.

why they are effective or ineffective). In this way, a long-standing criticism that social intelligence/knowledge tests fail to use testing formats that are sufficiently "social" in nature is addressed. This SKT also requires people to identify socially effective and ineffective behaviors from an ongoing stream of social behavior rather than to pick the best response to a social situation from among a list of possible responses that are provided to them. Arguably, then, our approach to testing social knowledge is more representative of "real life" than other testing approaches.

### **Potential Army/Military Applications**

There are several possible ways this basic research can be applied to address important Army/military needs. One would involve use of the social performance measure we have developed by supervisors or mentors to develop junior commissioned officers on the dimensions of social job performance that emerged in our research. The social performance measure could also be adapted for use as a self-development tool that could be administered on the Army's Intranet. Specific developmental suggestions for each social performance dimension could be created. Developmental suggestions could then be presented for those social performance dimensions on which an officer needs to improve, based on his/her self-assessed social job performance. This would have the virtue of providing a mechanism for development of interpersonal/leadership skills in a dispersed, web-based environment. Another possible application would involve adaptation of the SKT for training purposes. Specifically, the SKT could be used as a training needs assessment tool to determine an officer's social knowledge deficits. The scoring guidelines we have created for the SKT could then be adapted as learning points to be discussed either with a supervisor/mentor or in a group format with a trainer/facilitator.

This research also has applications to selection/promotion. In evaluating our theory, we will be determining the extent to which measures of various attributes correlate with various dimensions of social job performance. Some of these attributes (e.g., social intelligence, social planning ability, charisma, social motivation) may not currently be used in the Army's current selection/promotion procedures for its junior commissioned officers. This research could therefore be used to develop composites that may increase the accuracy with which the effectiveness of military officers can be predicted. And while the SKT is somewhat lengthy to administer, in principle, it could be used as a selection/promotion tool as well as a training needs assessment tool, assuming our research shows it to be valid.

Finally, the 20 social/leadership scenarios in the SKT could provide a foundation for several other assessment tools to be developed in the future. These tools might, for example, include a social skills measure, in which the action in the scenario is stopped at a critical point and the person being tested is asked to assume the role of one of the characters in the scenario. That individual's social performance in his/her assigned role could then be videotaped (or simply observed) and scored using scoring guidelines to be developed in the future.

## Accomplishments

Our accomplishments to date are as follows:

- *Developed taxonomy of social job performance requirements relevant to junior commissioned officers.* This involved extensive review of relevant literature and past PDRI project work, as well as a research study in which PDRI psychologists sorted examples of social job performance that emerged from that review into similar categories. Results of this sorting task were then analyzed using statistical methods to develop a two-level taxonomy of social job performance requirements. The final taxonomy included 7 broad dimensions and 20 more specific facets falling within those various dimensions.
- *Developed and pilot tested social performance measure based on that taxonomy.* We developed a 52-item social performance measure that can be completed by officers' superiors, peers, and/or subordinates (or, potentially, by the officers themselves). It measures the 6 social performance dimensions and 17 social performance facets from our social performance taxonomy on which ROTC cadets can be rated (since they comprise the group on which our theory will be tested). This social performance measure also includes several rating tips so that common errors made by raters (e.g., halo, leniency) can be minimized. The social performance measure was pilot tested on a small sample of ROTC cadre officers to help ensure its accuracy and relevance to 3<sup>rd</sup> and 4<sup>th</sup> year ROTC cadets.
- *Developed and pilot tested SKT.* Building on our social job performance taxonomy work, we developed and pilot tested a 26-scenario, video-based SKT. Based on results of a pilot test involving 22 ROTC cadets, we chose 20 scenarios for the version of the SKT that will be used to test our theory. Initial pilot test results were promising. Scores on the SKT were somewhat low. However, a substantial percentage of the targeted scoring criteria appear to be working well, and the range of scores obtained by the pilot test participants revealed that they varied substantially in their SKT scores. The SKT that we developed is presented on videocassettes, and includes detailed, carefully developed scoring guidelines.
- *Developed self-report social motivation measure.* We wrote 49 items that measure motivational aspects of the social knowledge/performance dimensions assessed in the 20 social scenarios comprising the SKT.

## Future Plans

Our intent is to administer a battery of measures assembled to test our theory of socially competent job performance to a sample of approximately 150 3<sup>rd</sup> and 4<sup>th</sup> year ROTC cadets and/or midshipmen. This will be done either during Fall, 2003, at several universities with ROTC programs, or during the Summer of 2004 using ROTC cadets attending the National Advanced Leadership Camp at Fort Lewis, Washington (with the latter requiring an extension of the Project's time frame). We anticipate completion of the project within six weeks after the data have been collected. Social performance measures will most likely be collected from peers if data are collected at universities because Navy and Air Force ROTC cadre officers would,

most likely, not be in a position to rate important aspects of the social performance of their cadets accurately due to limited opportunity to observe such behavior. If, on the other hand, data are collected at the National Advanced Leadership Camp, we will most likely collect social performance measures from ROTC cadre officers serving as trainers since they will have had an opportunity to closely observe the cadets' social behavior over a substantial period of time (about a month).

## **Social Structures Affecting Army Performance**

**Contract #:** DASW 0100 K 0016  
**Institution:** University of Maryland at  
College Park

**Contract Dates:** 8/17/2000- 8/16/2004  
**PIs:** David R. Segal and Mady Wechsler  
Segal

### **Research Summary**

The purpose of this research is the identification and analysis of changes in the international environment, in American society, in the U.S. Army, and in the American soldier, that are consequential for the fulfillment of Army missions. The research program consists of multiple projects organized into four inter-related areas: (a) research on American populations, (b) research on soldiers and their families, (c) diversity in the military, and (d) comparative military institutions. Most of our research on American populations has focused on the youth population from which the Army's recruits are drawn. In particular, collaborating with colleagues at the University of Michigan, we utilize the Monitoring the Future (MtF) database. This research program surveys about 16,000 high school seniors each spring semester and has been doing so since 1975, producing a rich archive of data on American youth. Sub-samples of seniors are then surveyed semi-annually for several years after high school graduation. Among the areas covered in these surveys are military-related attitudes and behaviors. In our research program on soldiers and their families we conduct surveys of soldiers in selected units and surveys of military wives. We also conduct interviews with soldiers and spouses, conduct observations of units in the field, and draw upon documentary materials in a variety of archives. In the area of diversity, our concern is with variations in adaptation to the military and its missions as they are affected by race, ethnicity, gender, and sexual orientation. We draw upon our own surveys and observations, secondary analysis of other surveys, and field observations. Regarding comparative military institutions, our goal is to draw upon the experiences of foreign military forces to identify cross-national similarities and differences as well as to learn from the experiences of others. Our approaches have been to encourage cross-national groups of behavioral scientists to engage in parallel research efforts in their own countries, to pool their knowledge, and to conduct surveys and interviews within the armed forces of other nations.

### **Contributions to Basic Research**

Our research on American youth has contributed to our understanding of attitudes and behaviors at the important life-course transition point between adolescence and adulthood, and particularly to our understanding of why some high school graduates elect to enter the military rather than following other trajectories, such as college or civilian employment. Our research on soldiers and their families has allowed us to use the military as a field laboratory to study and understand the range of tensions that exist at the interface between work life and family life, and the role that the family plays in work performance, satisfaction, and retention. Our research on diversity increases our understanding of how an organization that has traditionally drawn on the dominant majority sector of American society can adapt to the changing demographics of the American labor force, as we move toward a population in which no group constitutes a majority. Our comparative research program, focusing on similarities and differences in military forces

cross-nationally, contributes at the micro-level to our understanding of how soldiers (and other employees) adapt to such life-course experience as organizational down-sizing, at the meso-level to our understanding of how processes of organizational change take place, and at the macro-level to our understanding of how general social processes such as globalization affect military organization.

### **Potential Army/Military Applications**

Our research program on the attitudes and behavior of American youth is relevant for understanding the labor market environment within which the Army recruiting process takes place. The U.S. Army Recruiting Command has used the results of this research for several years, and it was recently cited in a National Research Council study on the youth population conducted for the Office of the Secretary of Defense.

Our research program on Army families has contributed to the development of ARI handbooks for family support groups and has assisted Army leaders who must provide support to families during deployments. This family research program was recently discussed with LTG LeMoyne (Army G-1) and LTG Cody (Army G-3) with regard to its implications for the Army Transition. More recently it was discussed with Col. Mike Pfenning for its relevance to the Army Well-Being Program. Much of our research on soldiers addresses adaptation to peace operations and is applicable to preparing units for such missions. Dr. David Segal has been called on frequently to make Officer Professional Development presentations to the leaders of units scheduled for deployment on peacekeeping missions. He was also recently invited to meet with the Reserve Forces Policy Board to discuss the role of reserves in contemporary missions.

Our research on diversity, and particularly on gender integration, has been used in ongoing policy discussions on the role of women in the military. For example, Dr. Mady Segal, who was a member of the Commission, presented our work to the Congressional Commission on Military Training and Gender-Related Issues. This influenced the decision by a majority of the Commissioners to recommend to the Congress that the Army be allowed to maintain its current pattern of gender integration in entry-level training. Mady and David Segal also have been consulted regarding sexual abuse problems at the U.S. Air Force Academy.

Our comparative research program serves as a source of lessons learned by variations in military organization. For example, David R. Segal has been asked to address the participants in an OSD summer study on the future of the officer corps in July 2003. He will speak about variations in ways in which military forces access, train, and educate their officers, and in relations between officers and enlisted personnel.

### **Accomplishments**

Our research on the American youth population has demonstrated a strong relationship between propensity to serve in the military and actual enlistment, but also a long-term declining trend in propensity to serve. We have demonstrated racial, ethnic, and gender differences in propensity, and in the relationship between propensity and enlistment. Most recently, we have shown a decline in perceptions that the military is a favorable work environment for women and minorities. Our data have also been used to address the hypothesis, widely discussed in the 1990s, that there was a "culture gap" between the American military and American society. Our

analyses show that the people who enter the military are in the mainstream of American society in terms of their attitudes.

Our research on soldiers focused primarily on personnel from the 10<sup>th</sup> Mountain Division and from the Reserve Components who were deployed on peacekeeping missions. We found that deployment had a negative impact on morale, but that multiple deployments did not reduce reenlistment intentions. We also found that participation in peacekeeping did not decrease the martial mindset of American soldiers.

In our research on women in the military, we have found that social values outweigh empirical evidence in public discourse, with certain arguments about gender integration persisting within new contexts despite evidence from research and military experience refuting the arguments. With regard to military families, we found that the effects of moving on military spouse employment vary by the rank of the soldier and the race and gender of the spouse. We have also found that first-term soldiers (in a small sample of infantry soldiers) tend to view themselves in terms of their family identities more than in terms of their identities as soldiers.

### **Future Plans**

We will be working on a number of projects during the next year. Our research on American populations will focus on a series of surveys at the U.S. Naval Academy, using modified versions of the Monitoring the Future research instruments. We will study the ways in which high school graduates who attend a military academy are similar to or different from their peers who attend civilian institutions of higher education in terms of their attitudes and values. We will also study the changes that take place during initial plebe socialization and during the four years of academy education. We will also be using the Monitoring the Future data bank to explore changes in the perceptions of the gender and racial climates of the American military by high school seniors.

Our research on American soldiers will involve the analysis of data we collected last year from first-term soldiers in two of the Army's interim brigades, focusing on the relationship between their former propensity to serve and motivations for service, and on the process of developing an identity as a soldier. We are also preparing a monograph on the demography of the American military to be published by *Population Bulletin*.

During the next year, our research in military families will include a study of military and civilian families' economic behavior and financial well being and an analysis of military family research (as a chapter in a book whose theme is how research designed to meet national security needs was an integral part of the evolution of psychology). We will be looking particularly at the implications of tied migration—the fact that the military relocates not only soldiers but also families—on the economic well being of military families.

Our major effort in the diversity area will be a book that Mady Segal is writing to capture findings from her thirty years of research on the integration of women in the military, involving synthesis of theory and research, analysis of data on basic training collected by the Congressional Commission on Military Training and Gender-Related Issues, analysis of public discourse on women's involvement in military activities, and analysis of the public policy formation process.

With regard to comparative military institutions, two efforts are underway. We are in the process of collecting data on members of the Japan Self-Defense Force who have participated in UN peacekeeping missions to increase our understanding of how personnel who historically have not been peacekeepers (in this case because they were precluded from out-of-area missions) adapt to this new role. We are also preparing an analysis of our Russian army downsizing data for presentation at a conference on the life course at Pennsylvania State University in the Fall.

# Construct Validating Aspects of the Theory of Successful Intelligence via a Test Battery for Measuring Mental Flexibility

**Contract #:** DASW01-03-K-0001  
**Institution:** Yale University

**Contract Dates:** Mar-01-03 to Feb-28-06  
**PI:** Robert J. Sternberg

## Research Summary

Robert J. Sternberg's triarchic theory of successful intelligence provides a broader conceptualization of intelligence than what is typically assumed by standard intelligence tests. The triarchic theory comprises three subtheories that deal with distinct but related aspects of human functioning. First, the *componential subtheory* deals with the more universal components of intelligence. These are the types of mental processes that intelligence tests have traditionally assessed. Second, the *contextual subtheory* deals with the types of mental processes that are needed to successfully adapt to the environment, to change (shape) the environment, and to select new environments if adaptation and shaping are not appropriate. And third, the *experiential subtheory* deals with mental flexibility – the ability to cope with novelty and to make routine processing more automatic. Mental flexibility plays a critical role in the successful application of the mental processes needed for adapting to, selecting, and shaping the environment in novel situations.

The goal of this research is to develop a multifaceted test of flexible thinking that measures how well one can apply the components of intelligence in relatively novel tasks and situations. Two basic paradigms for assessing mental flexibility are being investigated. The first paradigm conceptualizes flexibility from the perspective of the experiential subtheory, as just described. The test battery that will be created from this theoretical foundation will be validated against known measures of abilities that have predictable relationships with mental flexibility. The second is a "sensitivity" paradigm, which proposes an alternative conceptualization of mental flexibility. This alternative paradigm views mental flexibility as a person's sensitivity to subtle regularities that can be manipulated in the environment (or task). The research will be implemented in two phases. The first, formative phase will further develop and refine the tasks and methodologies in each paradigm. The second, summative phase, will investigate the nature of mental flexibility using the final test battery and refined methodologies.

## Contributions to Basic Research

The current research advances basic knowledge in the areas of intelligence and creativity, and helps to clarify the theoretical understanding of the mental processes involved in flexible thinking. The theory of successful intelligence differs somewhat from conventional theories of intelligence in its conceptualization of what mental flexibility is and where mental flexibility belongs in a theory of intelligence. The experiential subtheory of successful intelligence conceptualizes mental flexibility as a part of creative thinking, but not the only part. That is, while creative intelligence requires mental flexibility as an antecedent for convergent and divergent thinking, mental flexibility alone is not sufficient for creativity. The contribution of this research to basic science will be to clarify (1) the nature of the cognitive processes underlying mental flexibility, (2) the place of mental flexibility in the experiential subtheory, and (3) mental flexibility's relationship with other aspects of intellectual functioning (such as

convergent and divergent thinking, analytical and practical thinking, as well as traditionally assessed aspects of intelligence like abstract and verbal reasoning skills).

### **Potential Army/Military Applications**

A test of mental flexibility that assesses competencies that fall outside of the framework used by conventional tests of intelligence is potentially valuable for both selection and training.

*Selection:* Making promotion decisions at high levels of rank often means selecting from a group of people that are relatively homogeneous with regard to general intellectual abilities. If mental flexibility is truly distinguishable from general intelligence, then it may prove to be a critical factor in optimizing promotion decisions. Clarifying the link between mental flexibility and creativity has added potential to identify people's capacity for innovation – an important skill highly desired in senior officers.

*Training:* The importance of flexible thinking is evident in the function of military personnel at all levels. In the field, leaders need to adapt quickly to the new tactics of their opponents, to deal with changing commands from superiors, and to cope with unstable and unanticipated environments. Troops need to implement new orders quickly and effectively without being rigidly tied to previous ways of doing things. On the base, both leaders and troops need to accommodate constant changes in personnel and varying levels of ongoing change in the organizational structure. Research that builds on our understanding of the cognitive processes entailed in flexible thinking can be used to develop effective instructional programs that facilitate the use of flexible thinking strategies in a variety of contexts.

### **Accomplishments**

Given this is a new project, our major activities to date have been in preparation for data collection to begin in the fall of 2003. We have recruited at the research assistant level to assist with this and are also in the process of recruiting a software developer. We are currently preparing the initial pool of test items to be programmed ready for piloting and are reviewing the theoretical avenues suggested by the ARI research team at the May 13, 2003 ARI kickoff meeting in Washington DC.

### **Future Plans**

Our plans for the next year are to continue with the first phase of the project. We intend to (1) continue with the preparation of the test battery, (2) begin implementation and data collection for the formative phase of the research; and (3) further develop the theoretical specifications of the alternative "sensitivity" paradigm. Based on the result of this research and our pilot studies, we will modify, as needed, existing tasks and approaches in preparation for the summative second phase of the research.