



Foundational Research in the Behavioral & Social Sciences:

Marching Towards the Future



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12K run. U.S. Army National
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Foundational Research in Behavioral and Social Sciences: Marching Towards the Future

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ARI Special Report 73

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U.S. ARMY RESEARCH INSTITUTE

FOUNDATIONAL SCIENCE RESEARCH UNIT

The U.S. Army Research Institute for the Behavioral and Social Sciences (ARI) is the Army's lead agency for the conduct of research and development in the behavioral and social sciences focused on addressing personnel, organization, training, and leader development issues. ARI is a Field Operating Agency of the Office of the Deputy Chief of Staff, G-1, Headquarters, Department of the Army. ARI supports the DCS, G-1 via basic research, applied research, and advanced technology development aimed at improving Army readiness and performance.

The Basic Research program is managed within the Foundational Science Research Unit of ARI, and focuses on creating new knowledge and concepts in support of Army needs, through the conduct of foundational research (6.1) in high-risk, high-reward areas. Broad program goals are searching out and advancing state-of-the-art theory, measures, and methods in the behavioral and social sciences. This includes research that represents paradigm shifts as well as more incremental theory building. The basic research program provides the scientific basis for the Army to modernize the personnel testing, training, and leader development systems of the Army, as well as explore avenues for the Army to maximize unit effectiveness.

The Basic Research program is a critical link between the military and the scientific community within the behavioral and social sciences. ARI's researchers within the basic research program maintain close contact with ARI's applied research units as well as the foundational research organizations within the Department of Defense. This regular communication enables the basic research program to define new issues requiring fundamental research, ensures that the basic research program is coordinated across military services, and facilitates the transition of basis research results to applied research programs for eventual use by the Army.

The basic research program is focused on state-of-the-art advances in six research portfolios.

Research Portfolios and Goals

Personnel Testing and Performance

Identify and understand fundamental processes underlying stable individual differences related to Soldier success, and develop efficient, accurate assessment tools and classification measures useful in mass-administration testing environments.

Learning in Formal and Informal Environments

Advance theoretical understanding and develop specific learning methods to maximize the development, retention, and transfer of complex tactical/technical, perceptual, and interpersonal skills, via both formal and informal learning environments and experience.

Leader Development

Advance theoretical understanding of leadership and leadership development within the operational environment and at home station, and create leader development methods for maximizing the requisite cognitive, perceptual, and interpersonal skills for effective leadership across all levels of command.



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Organizational Effectiveness

Expand our knowledge of the complex social, cognitive, and behavioral processes, structures, and characteristics of multi-echelon organizations, and develop improved methods for identifying, measuring, and modeling these factors for predicting and improving organizational performance and effectiveness.

Socio-Cultural Capabilities

Develop theories and models of culture that can be used to improve understanding and prediction of individual perceptions, cognition, and behavior within different cultural contexts, and to develop improved processes for assessing culture and culture-related behavior and cognition.

Psychophysiology of Individual Differences

Understand underlying dissimilarities in physiological activity that gives rise to observable individual differences in behavior and to identify useful biological responses as they relate to psychological constructs while advancing understanding of the theoretical framework linking physiological and cognitive processes

Research Program Structure & Execution

Basic research at ARI is conducted through intramural, extramural, and collaborative mechanisms. ARI maintains robust support for extramural basic research through its Single Investigator Program. Extramural basic research is solicited annually through a Broad Agency Announcement. This report provides a listing and brief synopsis of ongoing and recently completed extramural basic research efforts, organized into the six research portfolios. Intramural basic research is conducted by FSRU research scientists and research fellows with the Consortium of Universities: this research will be incorporated into future reports. Finally, ARI provides support for behavioral science research at the military service academies, as well as collaborating with the Army Research Office on Multidisciplinary University Research Initiatives with a behavioral or social science component.

ARI's basic research program is responsible for maintaining an international behavioral science and technology watch, and maintains outreach efforts to Historically Black Colleges and Universities (HBCU) and Minority Institutions (MI).

Additional information about these efforts is available upon request.

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PERSONNEL TESTING AND PERFORMANCE

DR. LYNNE M. ROCHETTE, RESEARCH PORTFOLIO LEAD

The Army has historically undergone cycles of rapidly growing and contracting the force, and will likely continue to do so in the future. The Army has a constant need to access and retain high quality personnel throughout the force structure. To do this it needs to identify and assess aptitude and skill requirements for Soldiers and leaders, and to place personnel into jobs matched with their capabilities to encourage productivity and optimal performance in the Army. Current personnel tests assess general cognitive abilities, some vocational aptitudes, and an array of temperament dimensions, which provide good prediction of success in initial training and first assignment after training. However, improvements in test efficiency, accuracy, and coverage continue to be sought to allow for improved prediction of Soldier success, as well as the possibility of expanding the application scope to include prediction of collective performance, improvements in job classification, and occupational assignments. In order to achieve greater testing efficiency and accuracy, limitations of current testing methods and theory must be overcome.

The overarching goal of this research portfolio is to identify and understand fundamental processes underlying stable individual differences related to Soldier success, and develop efficient, accurate assessment tools and classification measures useful in mass-administration testing contexts.

Research objectives within this portfolio can be organized into three broad areas:
(1) *assessment methods*, (2) *measurement theory*, and (3) *personnel systems*.

Assessment Methods

ARI's Basic Research program seeks to explore the assessment of existing constructs implicated in Soldier and leader success to include cognitive complexity, cognitive flexibility, curiosity, creativity, spatial reasoning, social/interpersonal skills, and fundamental cognitive abilities. The Basic Research program also seeks to identify testing/assessment methods and associated statistical analysis approaches to accurately assess multiple constructs simultaneously to improve selection and classification techniques, as well as new and emerging maximal performance testing methods that resist socially desirable responding.

Measurement Theory

The Basic Research program seeks to explore the boundaries of existing test theory and develop novel contributions that provide for understanding of test context, variation in trait/ability expression, test-taker motivation and perspective, and other relevant facets of observed score variance. Developing a multi-level theory of selection and occupational classification processes to provide a better understanding of how individuals contribute to collective performance is also of top priority. Moreover, the program strives to develop job analysis theory to assess relatedness (i.e., similarities and differences) across many jobs in order to create overarching criteria for job classification and competency assessment while minimizing or eliminating reliance on subject matter experts.

Personnel Systems

ARI's Basic Research program seeks to advance the understanding of motivational, psychological, demographic, organizational, and societal factors that influence personnel enlistment, retention, and productivity.



Currently Funded Research

ARI's Basic Research program is currently funding five extramural research projects.

Brief descriptions of the contracts are provided below, with detailed research summaries of each contract provided on pages 3 – 16.

Social Trends and Social Change in the United States: Impacts on Army Manpower, Personnel, and Operations

(W91WAW-09-C-0077; 2009-2013)

Dr. David Segal (University of Maryland, College Park) is using existing military and civilian survey data to assess the intersection of organizational (social structure), environmental (social institutions), and technological domains in order to better understand social change processes and how work organizations and families affect one another.

A Theoretical and Empirical Framework for Linking Within-Person Variation in Trait Expression to Job Performance

(W5J9CQ-12-C-0011; 2011-2012)

Dr. Dan Putka (Human Resources Research Organization) and colleagues are developing a new personality measure that will examine how individual reports of personality traits vary depending on the situation, with the intent to improve the predictive ability of personality measures for outcomes such as work performance.

An Investigation of Person-Centric Relationships Using the Five Factor Model of Personality and Latent Profile Analysis

(W5J9CQ-12-C-0044; 2012-2014)

Dr. Jeffrey Conte (San Diego State University) and colleagues are using a new statistical approach to examine relationships among personality dimensions, intelligence, and military performance to identify observed patterns among individuals and extract understanding for the relationships among these constructs.

Testing the Situational Strength Process Model: The Important Role of Motivational States

(W5J9CQ-12-C-0036; 2012-2015)

Dr. Reeshad Dalal (George Mason University) and colleagues are examining how implicit and explicit environmental cues indicating the desirability of behaviors (situational strength) influence the link between an individual's personal characteristics and subsequent job performance.

Predicting Success with Elementary Cognitive Tasks

(W5J9CQ-12-C-0037; 2012-2014)

Dr. Meredith Frey (Otterbein University) and colleagues are developing a computer battery of tests that utilize culture fair, general ability measures (e.g., reaction time, working memory), which are believed to more directly measure the basic processes of intelligence and remain relatively free of formally acquired knowledge.



Social Trends and Social Change in the United States: Impacts on Army Manpower, Personnel, and Operations

Contract #: W91WAW-09-C-0077
PI: David R. Segal

Contract Dates: 09/29/2009-08/28/2013
Institution: University of Maryland, College Park

The present research seeks to extend our understanding of changes within social structures, particularly within the intersecting domains of population, organization, environment, and technology, and their implications for the U.S. Army. Focus is on the intersection of one specific and very important social institution and its population—our Army and its Soldiers—with society more broadly and with other institutional components of society, such as the family, the labor market, and educational institutions. The research conducted to-date has contributed to a better understanding of changes within social structures and cultural processes, particularly within the intersecting domains of population, organization, environment, and technology. More broadly, this project also contributes to basic knowledge of how American youth and young adults have been changing over time.

The present research seeks to extend our understanding of changes within social structures, particularly within the intersecting domains of population, organization, environment, and technology, and their implications for the U.S. Army. Within the Population domain, we are exploring trends in the general U.S. population, and particularly the demographic bases of support for the military institution and military operations; the demographics of the American youth population, from which the Army recruits its personnel; and the changing demographics of the military itself, including gender, age, racial and ethnic composition, family processes, and geographical distribution. We also consider the increasing use of Reserve Components, the effects of military service on former service personnel, sexual orientation integration of the force, and the role of the immigrant population in the military.

The Organizational domain refers to changes in formal and informal social organization, both in American social institutions

generally, and in the Army in particular, as well as the ways in which allied military forces and potential adversaries might be organized. It also refers to the ways that the professions are changing, particularly in terms of their educational requirements and expertise, and how these changes affect the military profession and the ways in which we conceptualize it. The organizational component of this research program focuses on both formal and informal manifestations of social structure, particularly social networks.

The Environmental domain refers to both the domestic (e.g., network of social institutions with which the military intersects, attitudes and values of the population, influence of family on decisions to enlist and to leave the service) and international environments (e.g., relationships with allies). Finally, we explore the domain of Technology, both in terms of how rapid progress in technology has changed the nature of war and development of counter measures to face an adversary using technology of an earlier generation. Ultimately, we

believe that this research will inform processes of Army recruitment, retention, and performance.

Research Approach

The research approach for this project makes use of existing surveys, including a range of survey data on military personnel as well as surveys that measure trends in the civilian sector. Military-related data come from surveys available through the National Archives, surveys tailored to research conducted by our Center for Research on Military Organization, and Defense Manpower Data Center-conducted surveys. For the civilian population, we use data from Monitoring the Future and the Census, supplemented as needed with data from the General Social Survey and the National Longitudinal Survey.

Accomplishments

Research conducted and published in 2009-2011 provided a variety of findings related to the functioning and outcomes of military personnel, military spouses, and counter-insurgency techniques. For example, past publications:

- Developed a model of factors affecting the military participation of women;
- Found substantial race, class, and gender differences in the impact of geographic mobility on military spouse employment; and,
- Examined how social network techniques can be applied to counter-insurgency efforts.

Publications in 2012 provided findings related to the impact of military service on service members, veterans, and military families, particularly within the changing organizational context of the

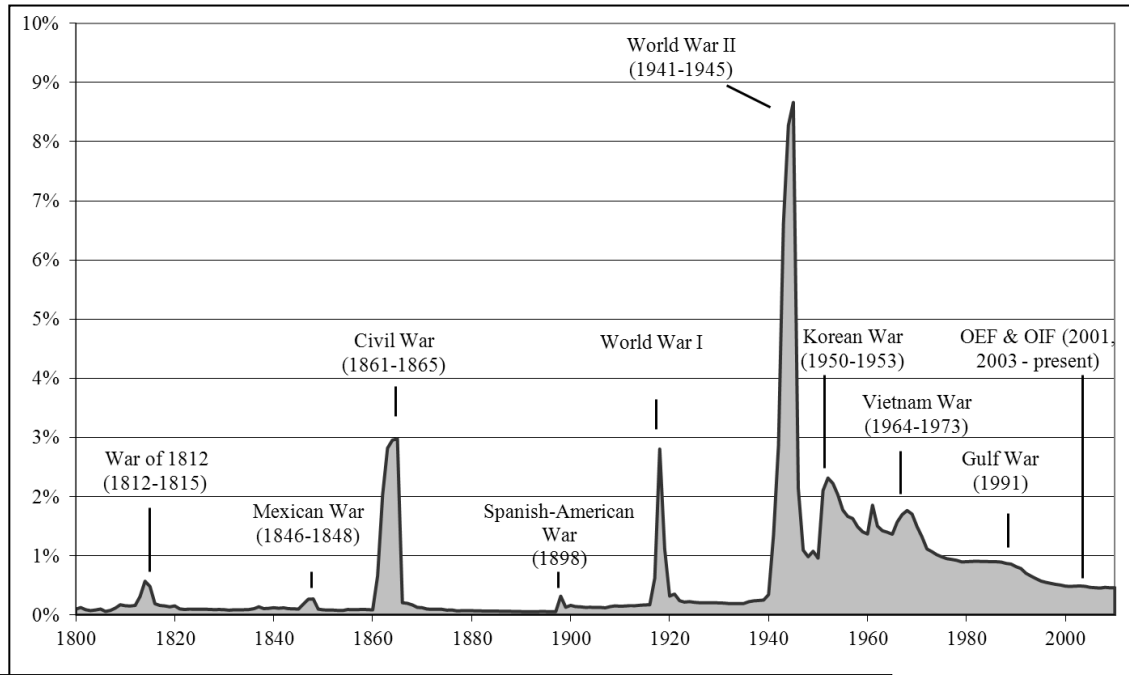


Figure 1. Participation in the U.S. Armed Forces, 1800-2010 (percent of total U.S. population). This figure appeared in Clever and Segal (2012) “After Conscription: The United States and the All-Volunteer Force.”

military in the era of the all-volunteer force (AVF) and the post-9/11 security environment. For example, Burk and Segal’s four-volume collection *Military Sociology* (2012) is a comprehensive collection of the most important works in the areas of military organization, civil-military relations, and the experience of war. Other publications examined the financial, manpower, and personnel considerations that emerged in consequence to the implementation of the AVF, highlighting the decreased level of participation in the military among the American population in recent conflicts in contrast to past draft-era wars (figure 1).

Publications and presentations currently in press or preparation will cover varying topics, including:

- Military service as a transforming influence in the life course trajectories of young people, with implications for understanding the effects that military service or non-service

may have in the context of a post-9/11 AVF;

- Increasing diversity of family forms among military service members (see Figure 2);
- The status and needs of military children since 9/11 and into the next decade as the drawdowns from OEF and OIF continue; and,
- An analysis of the currently available longitudinal data sources on military service finding several major knowledge gaps concerning current service members and veterans, particularly related to military families and veteran outcomes.

Contributions to Basic Research

The research conducted to-date has contributed to a better understanding of changes within social structures and cultural processes, particularly within the

intersecting domains of population, organization, environment, and technology. Much of the basic research agenda of the behavioral and social sciences involves understanding the nature and dynamics of social, psychological, and economic changes in society. These changes affect and are affected by the institutions that serve as the building blocks of society. This project focuses on the intersection of one specific and very important social institution and its population—our Army and its Soldiers—with society more broadly and with other institutional components of society, such as the family, the labor market, and educational institutions. The study of these intersections will contribute to our understanding of social change processes broadly, and how institutions affect each other. Thus, studying the interface between the military institution and the families of our soldiers contributes to our understanding of how work organizations and families

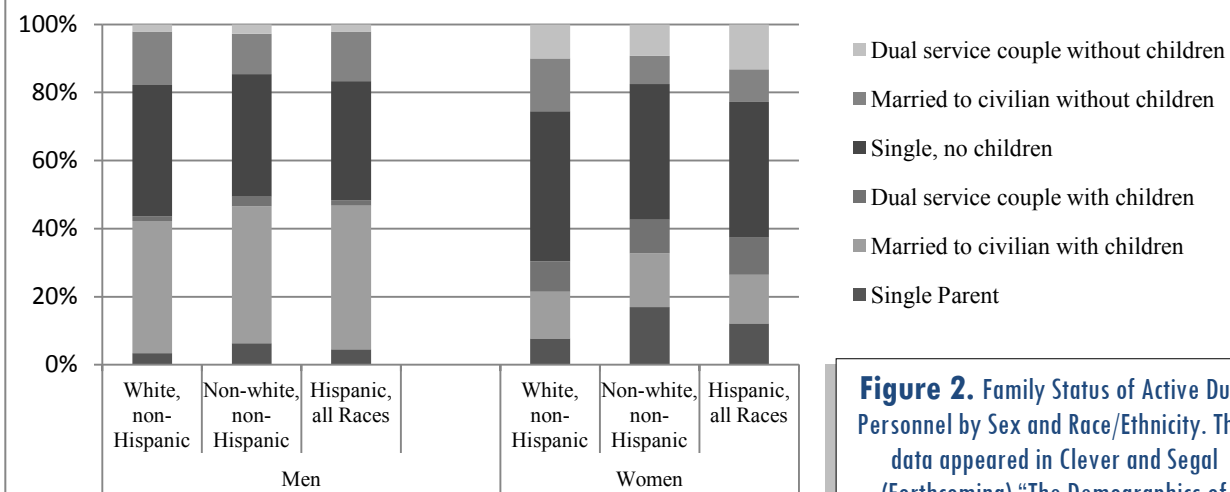


Figure 2. Family Status of Active Duty Personnel by Sex and Race/Ethnicity. This data appeared in Clever and Segal (Forthcoming) "The Demographics of Military Families and Children."

accommodate to each other. Studying the demographic changes in the labor force and how these affect the composition of the force builds knowledge in the area of diversity in work organizations and how to manage it. Using the military as a test-bed to study how those occupations changing both internally and in relation to society contributes to our basic understanding of the professions.

At the individual level, this project will also contribute to basic knowledge of how American youth and young adults have been changing over time. It has been common to speak of generational change. Our analysis contributes to our basic understanding of whether there have in fact been generational shifts, such as those that distinguished the World War II generation or the Depression Generation, which were marked by historical experiences of specific birth cohorts, or whether what we have been seeing are continual and fairly linear annual changes over a long period of time. To the extent that these changes are linear, this knowledge can help us anticipate,

for example, what the attitudes of American youth regarding desired employment characteristics are likely to be a few years in the future.

Additionally, the application of the life-course perspective helps us to understand how participation in a social institution shapes the lives of members and those associated with them after they leave the institution, regardless of the stage in life at which they leave the institution. The life-course reflects an ongoing series of transitions for people, and basic research done from this perspective helps us understand these transitions. Our work in this area also contributes to the development of methodological tools for the analysis of the life course of individuals.

Finally, our research in the domain of technology is particularly relevant given the abrupt changes that have occurred in recent years. Indeed, we are learning that our current conflicts are boots-on-the-ground engagements, and among the challenges to American forces is the development of soft skills as well as counter-measures to face an adversary using technology of an earlier generation.

Potential Army/Military Applications

The potential Army/military applications of our research findings range from very specific applications to broad generalizations that can be used to inform successful military policy, particularly in the context of the changing operational needs and pressures on military personnel in the context of the current drawdown from operations in Iraq and Afghanistan.

The 2012 conference paper "Identifying the Impact of Twenty-First Century Wars on Military Personnel and Veterans" identified several important differences between current service-members and recent veterans from previous generations, noting areas of serious knowledge gaps about the current generation of service members and veterans. In particular, changes to the operational environment, the operational tempo of deployments, policies regarding educational benefits, women's services and the end of DADT, the growing recognition of and scientific



knowledge about invisible wounds such as PTSD and traumatic brain injury, as well as broader societal transformations in the economy and the perception of the relationship between the military institution and civil society have all had important impacts on how our military operates, what our service members, veterans and their families need, and how military and civil society interact. These transformations indicate that data and research findings from the early years of the AVF are no longer relevant to address the changing needs of the military, service members, and their families. To make informed policy decisions in the context of these changes, the military will need new data that directly addresses these gaps in knowledge. The findings from this paper are being used to shape the research objectives that will be conducted over the next year on the impact of military service on the life course. Members of the research program's working groups have already used this information to reach out to existing longitudinal studies and propose content additions to ongoing surveys in order to address these gaps.

DeAngelis and Segal's (2012) findings on the role of changing military operational requirements in affecting minority exclusion policies carry important implications for current military policy debates, including potential changes to the ground combat exclusion of women. This research also has implications for recruitment approaches to address to the changing demographic composition of the American population, including the declining participation of African Americans and the growing participation of Hispanics and women, as well as religious minority and immigrant groups.

Final Summary

A primary focus in 2013 will be on furthering the work of the longitudinal military research program. The November 2011 meeting on the life course impacts of military service resulted in the development a program of research containing three working groups each aimed at developing research objectives and data collection plans targeting the impact of military service at different stages of the life course: namely, selection into the military and experiences within the military, the transition from active duty to veteran, and the long term outcomes of military service on veterans and their families. Since this meeting, the working groups have established work plans and data collection objectives and have identified several funding opportunities for which proposals have been submitted or are currently being developed. Members of the three working groups have been in communication with several major established national longitudinal surveys and are at various stages of progress in proposing additional content to these existing surveys in order to enhance the quality of data available to study the impact of military service on the life course. Our next steps are to formally submit proposals to these surveys for the addition of content and to secure additional sources of funding to support the proposed additions. The data that will be obtained from these survey additions will provide much needed information on the social functioning of the current and future generations of military personnel and veterans in the context of the drawdowns from Iraq and Afghanistan, particularly in the areas of employment, earnings, education, health and family stability.

Associated Publications

- Burk, J., & Segal, D. R. (eds.). (2012). *Military Sociology* (4 vols.). London: Sage Publications.
- Clever, M., & Segal, D. R. (in press). The demographics of military families and children. *Future of Children*.
- Clever, M., & Segal, D. R. (2012). After conscription: The United States and the All-Volunteer Force. *Sicherheit und Frieden (Security and Peace)*, 30(1): 9-18.
- DeAngelis, K., & Segal, D. R. (2012). Minorities in the military. In M. Matthews & J. Lawrence (Eds.), *Handbook of Military Psychology* (pp. 325-393). New York: Oxford University Press.
- Sandhoff, M., Segal, W. M., & Segal, D. R. (2010). Gender issues in the transformation to an all-volunteer force: A transnational perspective. In S. Cohen (Ed.), *The Decline of Citizen Armies in Democratic States* (pp. 111-131). New York: Routledge.



A Theoretical and Empirical Framework for Linking Within-Person Variation in Trait Expression to Job Performance

Contract #: W5J9CQ-12-C-011

PI: Dan J. Putka

Contract Dates: 12/12/2011 to 12/11/2012

Institution: Human Resources Research Organization

Co-PIs: Adam Beatty, Human Resources Research Organization;
Rodney A. McCloy, Human Resources Research Organization

Decades of research support that people behave differently in different situations. The focus of this research is on advancing the measurement of personality by more careful of consideration of situations. Specifically, this research proposes and evaluates a methodology for assessing multiple components of individuals' expression of their personality traits. These components include elements of personality that are stable across situations and those that vary depending on the particular situation that a person confronts. Historically, most of what the field of psychology knows about links between personality and valued outcomes such as job performance and employee turnover, are based on measures of personality that focus solely on the stable part of trait expression. As such, this research has the opportunity to inform the development of personality measures that offer increased potential for predicting outcomes of interest to the Army and other organizations.

People behave differently in different situations. This is supported by common sense and decades of psychological research. Situations we face play an important role in how we behave. For example, some situations inhibit a person from being outgoing, such as attending a lecture, whereas other situations may demand it, such as a working in a team to solve a problem. Despite the importance situations play in our behavior, psychologists also acknowledge that persons' behavior is also shaped by their enduring personal characteristics and experience. Such observations have led to a "person vs. situation debate" in many areas of psychology ranging from child development (think nature vs. nurture) to the study of personality.

Over the past few decades, psychologists have largely reconciled this debate and most now agree that the person and the situations he or she faces best explain a person's behavior.

Our focus is on advancing the measurement of personality by more careful consideration of situations. Throughout the history of psychology, the primary way psychologists have gained insight into personality is by observing or asking people to report on their behavior. That is, psychologists use a person's trait-related behavior to draw conclusions about that person's underlying personality. Specifically, psychologists often assess personality by administering a survey that asks people about past

behaviors that are indicative of one or more underlying personality traits. However, when people are asked to respond to items on such surveys, they are typically asked to do so without respect to a given type of situation in which that behavior occurred.

For example, imagine a survey question that asks you the extent to which you have been detail oriented in the past. Chances are your answer to that question may differ depending on the situations you consider when completing the survey. If you think of times when you were proof reading your tax returns or working on a highly visible project for your boss, the situation is going to demand attention to detail, whereas if you think of doing household chores, the demands for detail are less salient.

Despite such dependencies, common measures of personality make it impossible to pick up on such distinctions, and therefore limit understanding the extent to which individuals' trait expression depends on what they are doing.

In light of limitations of current psychological research and practice, the aim of this research is to develop and evaluate a new prototype measure of personality that is designed to

- (a) enhance understanding of how people's expression of various personality traits differs depending on the situations they face and how consistent they are in that expression over time, and
- (b) improve the capacity of personality measures to predict valued outcomes – such as persons' performance at work.



Research Approach

To evaluate the functioning of the new prototype measure, we will administer the prototype to individuals being recruited via Amazon’s Mechanical Turk (MTurk) web service (www.mturk.com). Mechanical Turk is a web service that allows researchers to conduct experiments online, and gather data from large diverse samples of respondents very quickly and cost effectively. We are administering the prototype, along with several other established psychosocial measures; to evaluate the functioning of the prototype and the quality of information it provides regarding various components of study participants’ personality.

Accomplishments

Given that this research is still in progress, there are no findings to report. Nevertheless, substantial progress has been made with regard to the development of the prototype measure.

The prototype measure is designed to assess four distinct aspects of two commonly assessed personality traits – conscientiousness and extraversion. Previous research has found persons’ expression of these traits varies across situations, and relates significantly to important outcomes such as how well persons perform their jobs and their effectiveness as leaders. Unlike commonly used personality measures – which provide just one “score” for a given personality trait such as conscientiousness – the prototype measure provides a far richer assessment.

The prototype produces four scores for each personality trait

Trait Elevation Score

This can be thought of as *the average degree to which a person exhibits a given trait across situations*. This component is most comparable to what is typically measured by standard off-the-shelf personality assessments and the only component of trait expression they generally provide. The dashed blue line in first panel of Figure 1 represents an average level of conscientiousness behavior across situations for a given person.

Trait Variation-Across-Situations Score

This can be thought of as *the degree to which a person varies in their expression of a trait across situations*. Conversely, it indexes how consistent the person’s trait-related behavior is across situations. The distance between the dashed blue lines in the second panel of Figure 1 provides an example of the amount of variation in conscientiousness behavior across situations for a person.

Trait Profile Score

This can be thought of as *the specific pattern or shape of a person’s expression of a given trait across situations*. Whereas the previous trait score reflects how much a person’s trait expression varies across situations, this component clarifies exactly how it differs across situations. For example, in third panel of Figure 1, data are displayed for a person who expresses conscientious behavior more in Situations 1 and 4, and less in Situations 2, 3, and 5.

Trait Variation-Within-Situations Score

This can be thought of as *the degree to which a person varies in their expression of a trait across occasions within a given situation type*. Conversely, it indexes how consistent the person’s trait-related behavior is within a given situation type over time. The vertical dashed blue lines in the fourth panel of Figure 1 provide an example of the amount of variation in conscientiousness behavior within situations for a person over time.

The prototype measure uses a novel format to derive the scores above for each trait. For each item on the prototype, an individual is asked to indicate the percentage of time over the past six months that the behavior described in the item is very descriptive of them, somewhat descriptive of them, or not descriptive of them in a given type of situation. Respondents are asked to provide this information for several different types of situations that were systematically chosen to reflect a diverse array of situation types. Examples include (a) pleasant vs. unpleasant situations, (b) working on difficult vs. easy tasks, and (c) working alone vs. working with others, and (d) working on an urgent vs. non urgent task.

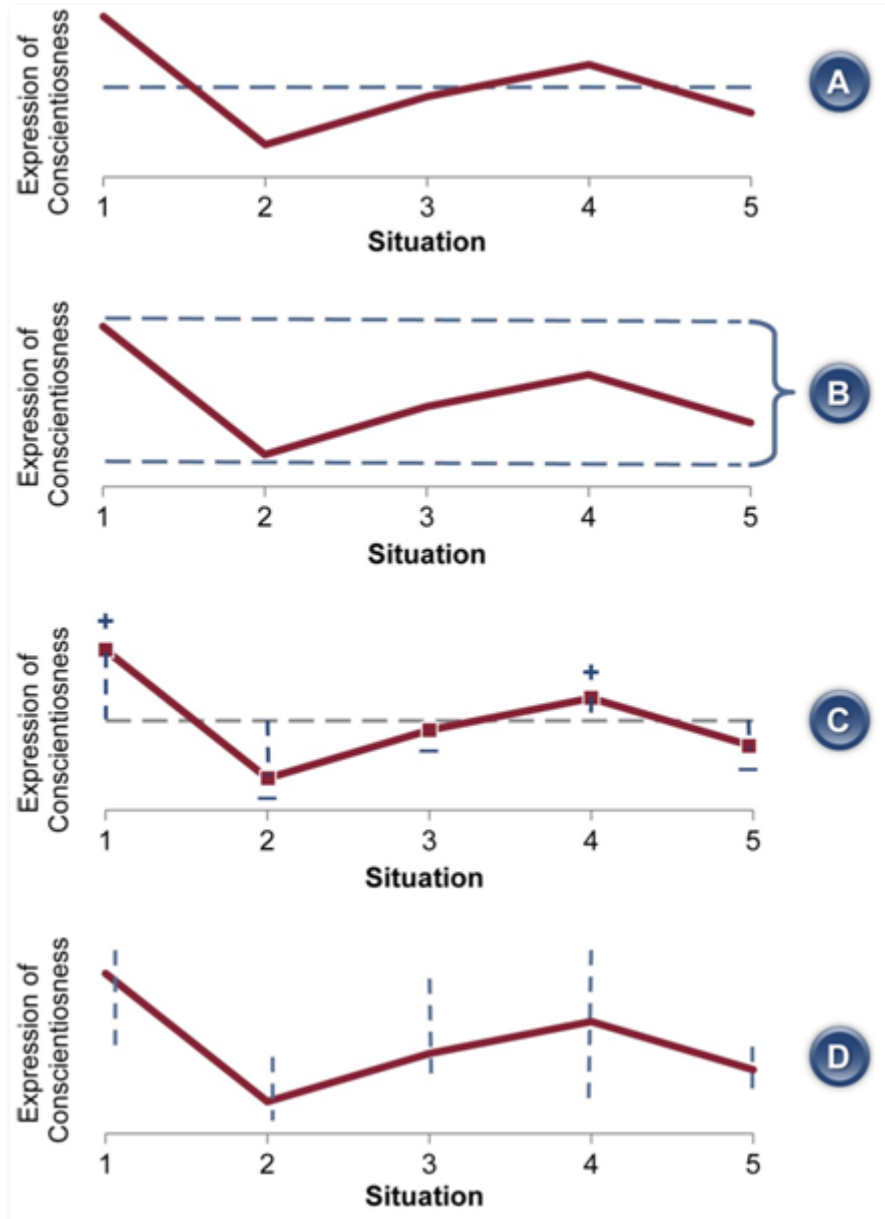


Figure 1. Example of Components of Trait Expression Assessed by the Prototype Measure

- A** Example of trait elevation component (average level of conscientiousness expression across situations).
- B** Example of trait variation-across-situation component (level of variability in conscientiousness expression across situations).
- C** Example of trait variation-profile component (shape of conscientiousness expression across situations: “+” on Situations 1 and 4 “-“ on Situations 2, 3, 5).
- D** Example of trait variation-across-occasions within situation component (level of variability in conscientiousness expression across occasions accounting for situational differences).



Contributions to Basic Research

This research has the potential to significantly increase psychologists' understanding of the role that persons and situations play in the expression of personality. It illustrates how a person's expression of their personality may reflect their own personal characteristics, the situations faced, and the unique combination of the two using a survey administered on only one testing occasion. If the four components of trait expression outlined in Figure 1 can be reliably and validly assessed on a single testing occasion, it would provide the field with a new and powerful means to measure and conceptualize personality and link it to other outcomes of interest such as job performance, leader effectiveness, and employee retention.

Potential Army/Military Applications

Over the past several decades, the U.S. Army has invested resources into developing methods for assessing personality traits. This emphasis has arisen in part from the need to identify psychological measures that can help improve the Army's ability to identify enlisted Soldier and officer candidates who are not only likely to perform well on the job, but also complete their active duty service obligation and re-up. Though much useful research has been conducted – and indeed has resulted in the operational implementation of measures for enlisted screening and selection of 4-year ROTC scholarship winners – all of these measures have assessed only the first component of trait expression described in Figure 1– trait elevation.

What has yet to be investigated is the potential for the other three components of trait expression to enhance the prediction of Soldier and officer performance and retention. Consideration of these additional components of trait expression could help improve the Army's ability to predict recruits' subsequent performance and retention through a more thorough assessment of their personality than has been possible based on measures used to date. Thus, this research provides a solid foundation for an alternative approach to personality measurement that complements and extends the Army's previous and current efforts in this area.

Future Plans

The plans for the upcoming months include gathering data on the prototype measure, testing formal hypotheses regarding its functioning, and producing a technical report documenting findings and discussing implications and extensions of this work.



An Investigation of Person-Centric Relationships Using the Five Factor Model of Personality and Latent Profile Analysis

Contract #: W5J9CQ-12-C-0044

Contract Dates: 9/27/2012 to 9/26/2014

PI: Jeffrey M. Conte

Institution: San Diego State University

Co-PI: Scott Roesch, San Diego State University

There is a broad consensus that personality dimensions predict a wide range of work-related behavior including job performance, training performance, and turnover. Overall, the objectives of the current project are to examine relationships among personality dimensions, intelligence, and military performance to identify patterns among individuals in what are sometimes called person-centered approaches. The multiple predictors and criterion or outcome variables will allow for the use of sophisticated analytic techniques that can aid in job assignment and classification issues in the military. This project will also be one of the first to use these sophisticated analytic techniques to link similar personality profiles with attrition, performance ratings, and work attitudes, which will aid in making more efficient and accurate Army selection and classification decisions.

Overall, the objectives of the current project are to examine relationships among the FFM personality dimensions, intelligence, and military performance to identify patterns among individuals in what are sometimes called person-centered approaches. Investigating such relationships with these person-centered approaches, which have rarely been used in organizational psychology or the military, has the potential to help develop knowledge about the relationships among these constructs, and ultimately, to help improve selection and classification decisions in the Army and other organizations.

Research Approach

Data for this project will come from the Army Class Longitudinal project completed by ARI's Personnel Assessment Research Unit. Archival data will be obtained on the following predictors: the Armed Forces Qualification Test (AFQT), the Tailored Adaptive Personality Assessment System (TAPAS, a Big Five measure), the Assessment of Individual Motivation (AIM), the Rational Biodata Inventory (RBI), the Work Preferences Assessment (WPA), and the Predictor Situational Judgment Test (PSJT).

Data will be obtained for the following criterion measures:

1. Attrition and performance during training
2. Research-only criterion measures of
 - a. Job knowledge,
 - b. Military occupational specialty (MOS)-specific and Army-wide performance ratings from training instructors and peers, and
 - c. Experiences and work attitudes measured by the Army Life Questionnaire (ALQ).

The most widely studied and agreed upon taxonomy of personality is the Five Factor Model (FFM). This model includes the following personality dimensions:

- *Conscientiousness* - achievement-oriented, responsible, dependable;
- *Agreeableness* - altruistic, cooperative, friendly;
- *Emotional Stability* - secure, composed, poised;
- *Extraversion* - sociable, talkative, energetic; and,
- *Openness* - curious, imaginative, independent judgment.

It is the result of a careful analysis of what most personality tests are trying to assess and statistical analyses of personality test information gathered over many decades.

There is now a broad consensus that personality dimensions included in the FFM predict a wide range of work-related behavior including job performance, training performance, and turnover. More specifically, research has shown that

- a) Personality differences play an important role in work behavior independent of the role played by cognitive ability;
- b) Personality is more closely related to motivational aspects of work (e.g., effort expenditure) than to technical aspects of work (e.g., knowledge components); and
- c) Personality is more likely to predict what a person *will do*, and ability measures are more likely to predict what a person *can do*.



The multiple predictors and criterion variables will allow for the use of sophisticated analytic techniques (Latent Profile Analysis, or LPA) in examining personality data in relation to other predictors and relevant Army outcomes. Thus, the research will involve a field study using multiple predictors and criteria from a large military data set.

Potential Army/ Military Applications

The analyses will make use of Latent Profile Analysis (LPA) to develop and identify specific profile sets that can subsequently be linked to important outcomes in the military. The LPA approach can be used to help with job assignment and classification issues in the military. That is, jobs are often clustered with task-based approaches, but this new person-centered approach can help to cluster, group, or classify individuals. The sort of profiles developed using LPA has the potential to help greatly with the sort of large-scale job classification that

is needed in the military. The personality characteristics of those placed into particular profiles that are then linked to military performance and retention can be used for subsequent selection and classification decisions. Overall, the results from this project can help the military to make better selection and classification decisions. The sample can be broken down into subsets of profiles, which can then be aligned with different job classifications.

The use of Latent Profile Analysis in the proposed project has the potential to provide an innovative examination of personality profiles and their potential links to Army outcomes. These profile groups may contribute to improving the selection and job classification of Army applicants. In particular, once profile groups are established, they can be examined in relation to performance and retention to assess for meaningful prediction based on these latent profiles or classes. In addition, other variables (e.g., AFQT) can be used as covariates along with the personality variables to predict performance and attrition.

A thorough literature review indicated that few if any studies have used LPA with military samples to predict performance and attrition. Therefore, this project will be one of the first to use LPA to identify homogenous personality profiles and to link such profiles with attrition, performance ratings, and work attitudes. By adopting a person-centered view and utilizing a new multivariate approach to investigating relationships among multiple personality dimensions, the results can help enhance the efficiency and effectiveness of selection and classification in the Army. In particular, the results can help the Army to identify and understand previously unobserved subpopulations within the overall Army Class sample, which can then help with making more efficient and accurate Army selection and classification decisions.

Future Plans

Research plans for next year include conducting analyses on the Army Class Longitudinal data and to begin investigating another data set, the Tier One Performance Screen (TOPS) project. The TOPS data will come from data that were assembled by merging TAPAS scores, administrative records, and Initial Military Training (IMT) data into a master database. For the TOPS data, over 60,000 applicants took the TAPAS, and over 53,000 were in the applicant sample primarily used for analysis in the TOPS data. In terms of criterion data, 3,592 had a criterion variable record, and 397 had valid IMT data. Thus, this data set will provide additional opportunities to examine relationships among personality variables, intelligence, and important military outcomes such as training performance, job performance, and retention of Army personnel.



Testing the Situational Strength Process Model: The Important Role of Motivational States

Contract #: W5J9CQ-12-C-0036

Contract Dates: 9/21/2012 to 9/26/2015

PI: Reeshad S. Dalal

Institution: George Mason University

Co-PI: Rustin D. Meyer, Georgia Institute of Technology

Soldiers are operating in ambiguous and fluid environments that require more personal discretion than has historically been the case. Situational strength refers to implicit and explicit cues provided by external entities regarding the desirability of potential behaviors. The current research addresses several important and inter-related gaps in the situational strength and motivation research literatures. This is the first step towards aiding the Army in selecting and classifying Soldiers who will be able to perform more effectively in ambiguous environments. This can further aid in the development of psychological theories to help researchers analyze Military Occupational Specialties.

Situational strength refers to implicit and explicit cues provided by external entities regarding the desirability of potential behaviors. In the current research, we extend our previous ARI-funded research by addressing several important and inter-related gaps in the situational strength and motivation research literatures. In so doing, we begin to understand how the Army can select and classify Soldiers who are able to perform effectively in ambiguous environments.

Our overall purpose is to examine the cognitive and emotional motivational processes through which situational strength operates. We provide a moderated-mediation process model that delineates the joint influences of situational strength and individual differences on motivational states and subsequent performance outcomes.

This process model is then extended into four related areas of inquiry.

First, we investigate how situational strength influences relationships between personality, motivational states (goals and self-efficacy), and various aspects of job performance.

Second, we examine the additive and multiplicative effects of situational strength emanating from multiple sources (the supervisor, organizational climate, and occupational characteristics) on goals, state affect, and task performance.

Third, we investigate emotional and behavioral reactions to both conscious and non-conscious forms of situational strength.

Fourth, we use the process model to explain a theoretically unexpected, yet empirically consistent, finding from our previous ARI-funded research: namely, individual differences are associated with deviant behavior more strongly in strong than in weak situations.

To address these questions, we use several different research designs: longitudinal surveys, laboratory simulations, and ecological momentary assessments. Our research has important implications for applied research in the context of modern warfare. These implications include providing a novel way to assess the underlying situational similarities and differences across various jobs (or Military

Occupational Specialties), understanding and predicting emotional experiences in changing environments, increasing Soldier productivity and “citizenship,” reducing Soldier deviance, and facilitating sense-making in ambiguous environments.

Research Approach

We use several research designs to answer our research questions. We use large-sample longitudinal surveys that facilitate complex comparisons across people. We also use ecological momentary assessments that facilitate comparisons within people across time and situations. In both these cases, we will use full-time employees as participants. We additionally conduct laboratory simulations that facilitate the manipulation of (and precise control over) situational cues. These simulations use college undergraduates as participants. All these research designs additionally help to isolate cause from effect due to their longitudinal nature and/or experimental manipulations.

Potential Army/ Military Applications

The construct of situational strength has profound implications for the U.S. Army because, according to recent statements about the changing nature of the Army’s role and structure, Soldiers are operating in environments that are more ambiguous and fluid, and that require more personal discretion than has historically been the case. For example, as described in the 2007 Army Posture Statement and both the 2006 and 2010 Quadrennial Defense Review Reports, the 21st century security environment is likely to be one of unpredictability



and uncertainty, with the Army facing irregular, novel and complex environments that often involve non-state actors who adopt unconventional methods.

These new challenges are motivating an Army-wide (i.e., systems-level) emphasis on Soldier adaptability, flexibility, and uncertainty management. Stated differently, current and anticipated future Army situations that Soldiers are likely to encounter are much “weaker” than those experienced traditionally—and the Army as a whole is re-orienting to reflect this decrease in situational strength.

The current research will aid in the development of psychological theories to help researchers analyze jobs (or Military Occupational Specialties) and assess the psychological similarities and differences across numerous jobs. In so doing, it will aid in the development of job analysis methods that do not rely solely on job descriptions from subject-matter experts and it will utilize novel testing approaches that do not rely solely on self-reports. The current research will also assist in the prediction of Soldier productivity and “citizenship” behavior through motivational and organizational factors. Importantly, the current research will help to assess the impact of changing Army missions on performance, satisfaction (morale), and discipline (versus deviance).

In addition to these human resources applications, the current research has applications in the areas of leadership and Soldier emotions.

With regard to leadership, the current research examines how leaders facilitate sensemaking and create shared understanding among Soldiers through downward feedback. With regard to Soldier emotions, the research enhances understanding of how emotions provide evaluative information about one’s environment and ultimately result in positive and negative behavior.

An important large-scale applied research project would involve the estimation of situational strength for a variety of individual Military Occupational Specialties. These estimates could then be incorporated into an online database similar to O*NET (the Occupational Information Network; <http://online.onetcenter.org>). The incorporation of situational strength into such a database would allow researchers and practitioners to improve Human Resources systems in the Army by more accurately assessing the likely validity of predictor variables, and by better estimating the likelihood of deleterious outcomes based on situational-strength misfit. The database would then be updated at systematic intervals (e.g., every decade) in order to track within-MOS temporal changes in situational strength as the Army continues to change in response to changes in its mission.

Future Plans

Over the course of the three years of this contract, we will be conducting four research projects. Our plans for the

next year involve making substantial progress on two of these projects and beginning work on the remaining two projects.

We have already obtained IRB approval for two of the four research projects at our academic institutions: one large-sample longitudinal survey (examining how personality influences job performance via goal setting and striving, and how these relationships are altered in strong situations) and one ecological momentary assessment (examining how deleterious personality traits result in negative emotions and, ultimately, deviant behavior in strong situations). For these two projects, we plan to accomplish the following steps in the next year:

- Make minor changes to the research protocols, obtain IRB approval for these amendments, and obtain approval from ARI’s Institutional Review Board
- Finish collecting data
- Begin analyzing data

The remaining two research projects include another large-sample longitudinal survey (examining the relative importance of various sources of situational strength--supervisor, workgroup, organization, occupation--on emotions and job performance) and a laboratory simulation (examining the impact of conscious and non-conscious forms of situational strength on thought, emotion, and behavior). Finally, for these two projects, we plan to accomplish the following steps in the next year:

- Finalize the research design
- Obtain IRB approval from our academic institutions and ARI



Predicting Success with Elementary Cognitive Tasks

Contract #: W5J9CQ-12-C-0037

Contract Dates: 9/27/2012 to 9/26/2014

PI: Meredith C. Frey

Institution: Otterbein University

Co-PI: Cynthia Laurie-Rose, Otterbein University

Measures currently used by the U.S. Army, the Armed Services Vocational Aptitude Battery (ASVAB) in particular, give emphasis to verbal knowledge and are susceptible to environmental effects, such as poor quality education. Researchers have turned to elementary cognitive tasks, or ECTs, in an effort to provide culture fair testing across broad strata of the population. The current research therefore seeks to develop a computer battery that more directly measures the basic processes of intelligence utilizing ECTs.

There is a need for the unbiased assessment of cognitive abilities to assist in selection of personnel. Measures currently used by the U.S. Army, the Armed Services Vocational Aptitude Battery (ASVAB) in particular, give emphasis to verbal knowledge and are susceptible to environmental effects, such as poor quality schools. The current research therefore seeks to develop a computer battery that more directly measures the basic processes of intelligence.

Researchers have turned to elementary cognitive tasks, or ECTs, in an effort to provide culture fair testing across broad strata of the population. Applied to more general abilities, ECTs demonstrate moderate predictive validity. Furthermore, they remain relatively independent of knowledge acquired through formal schooling. These tasks offer the advantage of utilizing rigorously controlled experimental procedures and can be computer-administered and precisely timed. Although ECTs also demonstrate some promise for predicting complex outcomes, improvements

are necessary to achieve a more prognostic battery. Such improvements can draw from recent research that has demonstrated a relationship between attention and intelligence. For example, researchers have found through the use of structural modeling techniques that sustained attention performance predicts cognitive abilities. Further, theorists postulate that working memory (WM) is strongly related to both attention and intelligence. In addition to the timed measures, the subjective experience of participants—assessed through workload inventories—may provide clues about the allocation of mental resources in demanding tasks.

While academia is only one of the many contexts in which intelligence in general, and specific cognitive abilities in particular, have demonstrated predictive validity, it is also the environment in which the utility of cognitive ability is most clearly and firmly established. Therefore, while the ultimate goal of this research is to employ ECTs in the prediction of success in a variety of complex environments, the use of

academic achievement as a starting criterion is certainly justified. Once the battery of tasks employed here is confirmed to be both useful and unbiased in an academic setting, extension of the research beyond the college campus is desired.

Research Approach

We seek to establish a battery of processing speed, working memory, and attention tasks that can be used to predict complex achievement outcomes. These tasks, which are measuring the basic mechanisms of cognitive functioning, have the advantage of being less information laden and are likely to demonstrate smaller racial/ethnic group differences than do more traditional assessments.

We plan to collect data from 600 participants over a two-year period on established reaction time, stimulus discrimination, working memory, and attention tasks, as well as obtaining estimates of mental workload, fluid reasoning ability, and academic achievement. While we seek to avoid measuring learned information, we intend to employ tasks that are quite difficult (see Figure 1). We will aggressively recruit minority and male participants from a nonselective university in order to diminish problems due to restriction of range and to establish the presence or absence of group differences in the cognitive task battery and/or the achievement criterion. The predictive validity of the basic task battery will be examined across sex and racial/ethnic groups, and workload data will be used to investigate resource allocation in very demanding tasks.

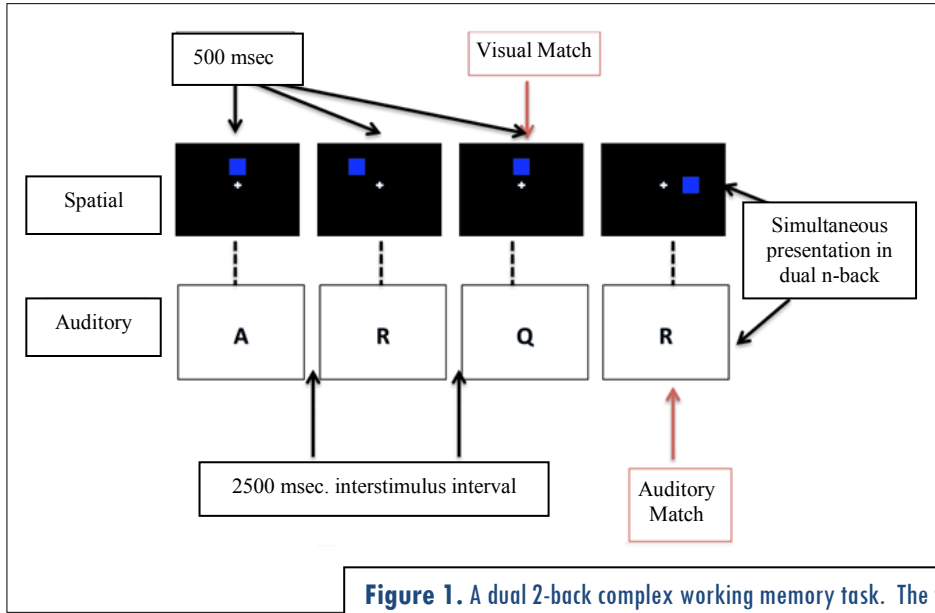


Figure 1. A dual 2-back complex working memory task. The task requires that participants simultaneously process and remember the location of blue boxes that appear onscreen and letter sounds that are presented over headphones. Every time the location or the sound matches one presented two items ago, the participants are required to press a button that indicates a match.

Potential Army/ Military Applications

While the ASVAB is a good measure of general ability and is useful at predicting academic ability in addition to the expected military performance, it relies heavily on learned information in many subtests, despite removal of the numerical operations subtest and the addition of assembling objects. Furthermore, in a large sample, the ASVAB has demonstrated significant racial group differences on both mean scores and on the prediction of relevant criteria. It is then a primary purpose of this research to develop a test battery to predict achievement in a general population independent of the measurement of learned information. The ultimate goal of this line of inquiry is to establish a test that can be used for soldier recruitment, selection, and assignment that is relatively content-free and demonstrates minimal group differences and predictive bias.

It is imperative that the Army be able to quickly identify those individuals who possess the cognitive skills needed to succeed in the military environment. Assessing Soldiers and recruits on the basis of more basic cognitive processes allows for an objective evaluation of potential without incorporating environmental factors. Because the battery is designed to be more culture-fair, it is likely that this battery of cognitive tasks will show much smaller, even non-significant, racial and ethnic group differences. If group differences do become evident, the more targeted tasks allow researchers and developers to directly measure the cognitive processes responsible for the differences and develop training methods to remedy such differences.

Future Plans

The new elements of the ECT task battery were successfully programmed. Beginning in February 2013, we will start data

collection on a university sample of compulsory subject pool students. Following the initial data collection phase, expected to last eight weeks, we will expand our subject recruitment via diversity organizations to increase minority and male representation in the sample.

We will use the Summer 2013 period to analyze our initial results and make modifications to the tasks we have employed to maximize their utility in predicting complex achievement outcomes. In particular, we may adjust the difficulty of some of the tasks in order to more precisely replicate the demands of complex test items without including references to learned information.

We plan to present the results of the initial research at two conferences in May and December 2013, where peer feedback may suggest additional avenues for our research extending into 2014.



The operating environment of the Army over the last ten years has created significant pressure on the Army training and educational institutions and individual Soldiers and leaders to maximize all opportunities for learning. These pressures will continue in the future as the Army reduces its number of personnel while also fulfilling the necessary emphasis on a diverse spectrum of operations (e.g., combat, security missions). In addition to defensive and stability operations, non-state adversaries that embed within local populations will continue to present unique challenges for detecting threats to U.S. and coalition personnel. Soldiers and leaders will be responsible for developing a broader array of skills and to higher levels of proficiency earlier in their careers. This will require a sustained focus on maximizing learning from formal learning environments, including individual or collective classroom training and technology-delivered training, while reducing the length of time to achieve skill mastery. Uncertainty about future operational environments will also require all Army personnel and units to identify critical operational areas in need of change/development and to learn quickly from informal learning experiences, including their battlefield experiences, mentoring, shared experiences of others, and self-development.

The overarching goal of this research portfolio is to advance theoretical understanding and develop specific learning methods to maximize the development, retention, and transfer of complex tactical/technical, perceptual, and interpersonal skills, via learning from both formal and informal learning environments and experiences.

Research objectives within this portfolio can be organized into three broad areas:
(1) *learning theory*, (2) *learning methods*, and (3) *learning assessment*.

Learning Theory

ARI's Basic Research program strives to develop longitudinal theory and measurement approaches to understand change in an individual's knowledge/skill development, retention, and near and far transfer over time, as well as the individual's underlying learning processes (e.g., motivation, engagement, self-regulation, affect). Enhancing such theory and methodology both within and across a variety of learning environments (e.g., formal training, on-the-job experiences, self-development) is of top priority. The Basic Research program also seeks to develop and refine theory explaining how the effectiveness of different learning methods may vary by the learning domain (e.g., tactical/technical, interpersonal, or perceptual skills), individual differences of the learner, instructor characteristics, and contextual factors external to the learner.

Learning Methods

The Basic Research program seeks to develop innovative theory and learning methods to tailor training to a given learner or team's needs in order to enhance training effectiveness and efficiency, as well as to maximize collective learning processes and outcomes for individual, team, and unit tasks.

Learning Assessment

ARI's Basic Research program strives to develop measurement techniques to objectively and/or automatically assess learning processes and learner performance/progress in a variety of training domains, within both individual and team training environments. Moreover, the program seeks to develop measurement techniques to assess metalearning ('learning to learn') and identify factors that impact metalearning in different learning environments.



Currently Funded Research

ARI's Basic Research program is currently funding four extramural research projects.

Brief descriptions of the contracts are provided below, with detailed research summaries of each contract provided on pages 19 – 30.

A Research Plan to Understand the Impact of Training on Performance

(W91WAW-09-C-0081; 2009-2013)

Dr. Susan Archer (Alion Science and Technology) is investigating the relative effectiveness of different learning methods and how their effectiveness is dependent on factors such as skill type being trained, task complexity, trainee characteristics, and learning outcome of interest. Further, this research seeks to formalize these identified relationships between learning methods and the moderating factors in a computational modeling tool to support future training research and design.

Training as a Catalyst for Field-Based Learning: An Integrated Theory, Principles, and Program of Research

(W5J9CQ-12-C-0048; 2012-2015)

Dr. Scott Tannenbaum (The Group for Organizational Effectiveness, Inc.) and colleagues are developing a theory of how formal training can be used as a catalyst for field-based learning. Specifically, this research will empirically examine how to best train learners to recognize and capitalize on learning opportunities while in the operational field environment, and the role that individual differences of the learner and contextual factors play in this process.

Exploring the Use of Visual Features and Recognition Strategies in Perceptual Expertise

(W5J9CQ-11-C-0047; 2011-2016)

Dr. Lisa Scott (University of Massachusetts, Amherst) and colleagues' work focuses on how individuals acquire perceptual skills, investigating what feature-level information of an object and cognitive strategies experts employ in order to make fast, precise recognition decisions. Specifically, this research seeks to apply this knowledge gained to develop learning methods for developing these visual perceptual skills and strategies in individuals with varying degrees of expertise.

The Effect of Threat on Task Performance: Testing the Threat-Inducted Potentiation of Prepotent Responses Model

(W5J9CQ-12-C-0046; 2012-2015)

Dr. Stephen Harkins (Northeastern University) focuses on identifying the processes that mediate the effects of threat on task performance; and, thus, provides implications for how to design training to improve task performance when facing threat.



A Research Plan to Understand the Impact of Training on Performance

Contract #: W91WAW-09-C-0081
PI: Susan Archer

Contract Dates: 09/29/2009 to 09/29/2013
Institution: Alion Science and Technology

Decisions on how to efficiently train a workforce require an understanding of the factors that impact training effectiveness, cost effectiveness, need for periodic retraining, and training transfer. The overall objective of this research is to understand the relationships between training methods, task factors, and training effectiveness. Task factors are predicted to mediate the impact of different training methods. This project uses task type and task complexity to understand the impacts of training manipulations on performance. Human performance modeling tools can be used to explore the tradeoffs between training techniques as they relate to various measures of effectiveness. The results of this research effort will provide a framework and evidence base for identifying effective training methods for various Army tasks.

Researchers investigating the field of training effectiveness are familiar with common challenges – different operationalizations of training methods, scarce focus on training transfer, and the lack of a systematic comparison of training options, especially across studies and disciplines. There is a need to look across these different studies to draw conclusions and uncover patterns across existing training effectiveness research so that researchers understand what evidence exists, how strong it is, and where the gaps lie. Many factors interact to influence and mediate the effectiveness of training. These variables typically include *individual factors* such as experience level, abilities, trainee expectation and motivation; *training factors*, such as delivery mode, instructional methods, quantity of training, and feedback strategies; and *task factors*, such as the task type, task

complexity, and the types of knowledge and skills involved. Of the factors that impact training effectiveness, the training community has more control over the training methods.

The overall goal of this research is to understand how performance outcomes can be improved for different types of Army relevant tasks through the use of training methods tailored to the target task. By identifying quantitative relationships between training methods, individual factors, and task factors, this research can provide an evidence base to guide training design decisions. For a given task, what training methods or combinations of methods are more effective in terms of transfer performance and which can be used to reduce training time while still achieving criterion performance levels?

This understanding of the training landscape can be used to directly compare methods and develop algorithms to predict the usefulness of different combinations of training method, trainee characteristic, and task type. The result will be a better understanding of how training design impacts effectiveness which will enable program managers to determine how to develop or augment training to support their specific tasks. The Army can capitalize on this knowledge in Human-System Integration tools to explore the tradeoffs between training techniques as they relate to various measures of effectiveness.

Research Approach

The research was bounded to focus on actionable evidence. We focused on studies that addressed training transfer. In other words, how well are trainees able to *apply* what they learned once they were in the field? We emphasized cognitively complex Army-relevant tasks and used the following question to guide our research: If you have a classroom and a simulation environment, how do you effectively use them to enhance training transfer?

We combined literature review with meta-analyses and experimentation. The literature review provided insights on the effectiveness of training methods which will be translated into heuristics and guidelines for selection. This was complemented with quantitative meta-analyses findings on the relative usefulness of select training methods and how different factors moderated their usefulness. Experiments were conducted to fill research gaps and disentangle results. The final phase involves development of a database and algorithms to organize the research findings and inform training development decisions.



Accomplishments

Multiple meta-analyses were conducted to generate estimates of the relative effectiveness of targeted training methods and the factors that moderate effectiveness. Six training methods associated with managing training difficulty and promoting transfer were included: part-task training, task difficulty sequencing, training wheels, scaffolding, learner control, and exploratory learning. Five experiments successfully filled gaps identified in the meta-analyses. These studies addressed gaps associated with exploratory learning for different levels of instructor interaction, worked examples for a cognitive planning task, part-task training for sequential and time-sharing tasks, adaptive sequencing compared to fixed and constant sequencing, and adaptive remediation in response to errors as opposed to error prevention training. The experiments had several common elements: 1) performance was measured on both near and far transfer tasks, 2) trainee characteristics such as experience, education, and problem solving ability were taken into consideration, and 3) the tasks were challenging and complex, ranging from monitoring multiple unmanned vehicles, to teleoperation of a ground vehicle, to making planning decisions regarding unmanned vehicle allocation.

The meta-analyses and experiments have produced a wealth of findings related to training effectiveness. These findings are related to part-task training, training delivery of complex tasks, increasing difficulty across training, preventing errors early in training, worked examples in complex military planning, scaffolding removal schedule, exploratory learning, learner control, and adaptive training. Due to space limitations, only a sample of these

results and their implications for Army training are described below.

When part-task training consisted of selective parts (but not all parts) prior to whole task training, part-task training was effective, even when timesharing between the tasks was involved. The implication is that training might be streamlined by focusing on training selective parts without sacrificing transfer performance. Practicing tasks separately was beneficial for transfer to the whole task even when the individual parts were timeshared in the whole task. We addressed questions about when to use part-task training for a concurrent but non-interacting task (e.g., teleoperating an unmanned ground vehicle while concurrently monitoring for and identifying potential threat vehicles). Interestingly, results supported a transfer benefit for part task training to the live environment. This augments findings of the part-task training meta-analysis that revealed a non-significant cost to part-task training relative to whole task in this condition. The cost savings of implementing training with these results in mind are potentially significant.

The exploratory learning meta-analysis showed an overall significant transfer benefit for guided training relative to less-guided exploration. However there were some significant exceptions. Less-guided exploration provided a significant transfer benefit over more-guided training when:

- Training was on a computer or a simulation and a manual was provided;
- Tasks were more procedural rather than conceptual;
- Transferring to a more complex task than the training task.

These results highlight the situations in which it is more beneficial to use a less-guided exploratory training

approach, helping training developers choose the best option for their situation. The benefit of exploration-based training in certain conditions was confirmed in a military relevant experiment using a digital interface to interact with unmanned vehicles (figure 1).

Regardless of how exploratory training was implemented, when transferring to a new, more complex scenario with new tasks and procedures, exploratory training outperformed non-exploratory training. This finding held true for both college and non-college demographics. Consistent with the findings from the exploratory learning meta-analysis, experimental evidence suggests that it is beneficial to have trainees learn and practice basic procedures on their own, before starting a training program on the more complex aspects. When done correctly, training which involves active exploration by the user benefits transfer to tasks likely to be encountered in the field. This not only has the potential to aid on the job performance, it has the potential to reduce costs associated with fully instructor-guided courseware.

Contributions to Basic Research

Results from this project contribute to basic research in a number of ways. A better understanding of the effect of training methods and task factors on performance will add to the training effectiveness knowledge base and provide a foundation for empirically based training design guidelines. Meta-analysis results make an important contribution to basic research by organizing and synthesizing the empirical evidence across studies investigating related training transfer research.



Figure 1. Soldier Machine Interface used in digital skills training research

Potential Army/Military Applications

Decisions on how to efficiently train a workforce require an understanding of the factors that impact training effectiveness, cost effectiveness, need for periodic retraining, and training transfer. The results of this research effort will provide a framework and evidence base for identifying effective training methods for various Army tasks. A framework and model that provides heuristics and quantitative algorithms relating training methods to performance for different types of tasks could be transitioned into a number of products and widely applied in Army and other military training research and practice. For example, it has potential to provide training program managers and unit level training staff with guidelines for the best ways to develop or augment training for specific task types.

An example long term application would encode the heuristics into a system that provides a capability for a subject matter expert with domain knowledge but limited training expertise to query the system and receive training strategy recommendations for a particular task and population.

The results of this research would have broad application in:

- ARI and other military and civilian applied training research programs.
- ARI and other military programs developing training design guidelines to help training managers and trainers identify the best ways to train specific task types.
- Human-system integration tools that explore the tradeoffs between training methods as they relate to retention, performance, and transfer measures.

Although transfer of training is a rich research topic, there has not been a systematic review of the impact of various training methods on transfer performance in general, or comparison of methods for more specific near and far transfer objectives. Research comparing the effectiveness of training methods for different task or skill types is also limited. Findings from the six meta-analyses conducted to date provide a synthesis of empirical studies comparing the effectiveness of selected training methods moderated by a wide range of trainee and task factors, skill types, transfer criteria, and method implementation approaches.

The research synthesis also provides an evidence base to identify training methods, task areas and moderating variables where additional research is needed to evaluate effectiveness. General research gaps include limited findings comparing the effectiveness of training methods for different task or skill types and limited research comparing the effectiveness of training methods for acquisition, near transfer and

adaptive transfer tasks. Our experimental framework expands on core themes represented in the training literature by 1) investigating tradeoff issues between training methods focused on very specific task objectives and those aimed at flexibility for transfer of knowledge and skills; and 2) accounting for potentially relevant individual differences in each study. The five experiments address training method specific research gaps in the context of complex cognitive skills in realistic Army tasks. The results from experiments provide additional knowledge on the relative effectiveness of exploratory learning, part-task training, worked examples, adaptive training, and error prevention for training Army relevant skills.

The end products of this research will include: 1) a better understanding of the factors that impact the effectiveness of training methods on transfer performance; and 2) an evidence base defining the relative impact of different instructional strategies on training transfer for specific task characteristics.

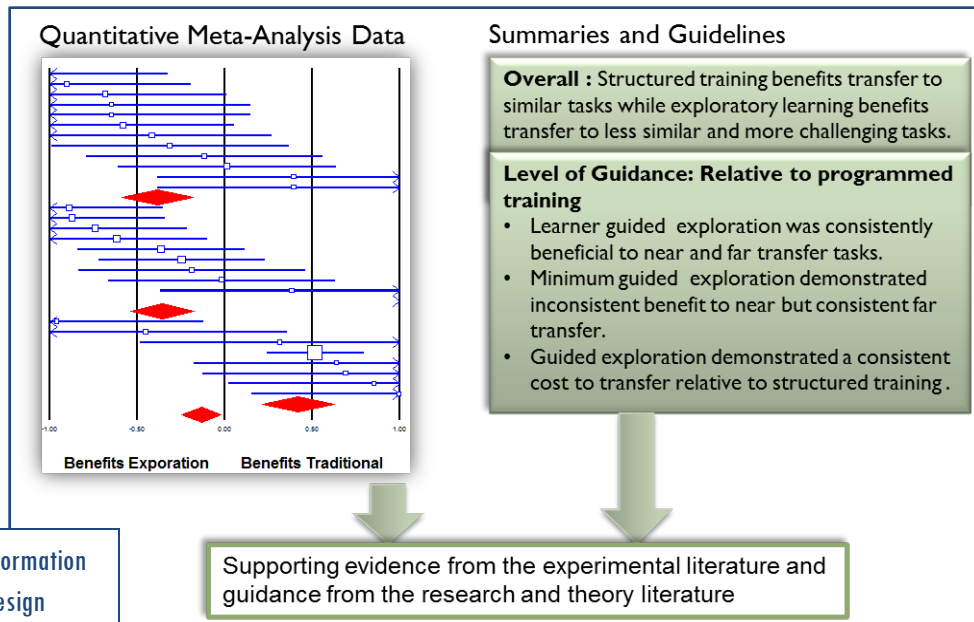


Figure 2. Example of information provided by the Training Design Guidance Tool

Future Plans

Human performance modeling tools can be used to explore the tradeoffs between training techniques as they relate to various measures of effectiveness. By taking the computational algorithms developed in this effort and embedding them within human performance modeling tools analysts can ensure that training considerations are an integral part of human-system integration during systems acquisition. The combined tool and algorithms should be able to capture the impacts of performance moderators that have different effects over simulation time or are dependent upon some other simulation variables (such as training method, task difficulty, or type of task). Analysts concerned with the acquisition of new weapons systems can get closer to predicting how training can influence human technical task performance when working with various systems. In particular, they could predict which instructional strategy (or combination of strategies) results in the most efficient and effective performance.

FY13 will result in two main products that incorporate findings to date and package them in a usable tool. We will develop a *Training Design Guidance Tool* that will organize training effects knowledge with associated supporting evidence (see figure 2, above). A database of research findings will form the foundation for this training design guidance tool. The tool will visually detail available empirical evidence regarding the quantitative effects of training methods on performance and identify moderators of performance for different task types and individual factors. The quantitative values will be based on the results of the previous meta-analyses and experimental research. In addition to qualitative evidence, the tool will provide narrative guidelines based on existing research, theory and/or practice and the basis for the quantitative and qualitative statements. The user-friendly dialog-based tool will guide users to identify appropriate training strategies for different combinations of task and individual factors based on available research results.

We will also develop algorithms relating information about training methods, individual factors, and task factors to performance. We will use a combination of literature, meta-analysis results, and experimental data from the previous Phase I and Phase II efforts to extract relationships that indicate the performance impact of various training strategies. We will analyze the results to create algorithms that predict performance for different training methods given information about the task to be trained and potential trainees.

Associated Publications

- Hutchins, S., Wickens, C.D., Carolan, T., & Cumming, J. (*in press*). Error Prevention Training Support: Meta-Analyses of Transfer. *Human Factors*.
- Wickens, C.D., Hutchins, S., Carolan, T., & Cumming, J. (2013). Effectiveness of part-task training and increasing-difficulty training strategies: A meta-analysis approach. *Human Factors*, 55(2), 461-470.



Training as a Catalyst for Field-Based Learning: An Integrated Theory, Principles, and Program of Research

Contract #: W5J9CQ-12-C-0048

Contract Dates: 08/29/2012 to 08/28/2015

PI: Scott Tannenbaum

Institution: The Group for Organizational Effectiveness, Inc. (gOE)

Co-PIs/Subcontractors: John Mathieu (University of Connecticut), George Alliger (gOE),
Eduardo Salas (University of Central Florida)

It is unrealistic to expect pre-mission training to prepare Soldiers and leaders to be fully ready for all possible field contingencies. It is therefore imperative that we maximize and accelerate their ability to acquire new knowledge and expertise when in the field. The premise of this research is that formal training can be enriched to serve as a catalyst for subsequent field-based learning. The research objectives are to build and test an integrative model of training to accelerate field-based learning. The ultimate goal of this effort is to yield innovative advancements which could be integrated into a wide range of Army training programs for Soldiers and leaders. Simply put, this effort seeks to maximize the extent to which training prepares soldiers and leaders to learn during their subsequent field assignments.

It is unrealistic to expect pre-mission training to prepare Soldiers and military leaders to be fully ready for all possible field contingencies. Thus, it is imperative that we maximize and accelerate their ability to actively acquire new knowledge and expertise when in the field, which we refer to as field based learning (FBL).

Existing research related to FBL is informative but fragmented in that various aspects of FBL have been studied under a variety of different terms, including continuous learning, experiential learning, self-directed learning, and active learning. Although there are differences in how these terms are defined (e.g., whether they are: activities related to a specific role or domain, on-going activities, part of formal or informal learning) there is a great deal of overlap among the constructs, their theoretical foundations, nomological networks, and practical implications. It is important to note that the contributions of researchers in these

areas have been non-trivial, including their contribution to our understanding of the situational and personal characteristics that might influence FBL behaviors. However, in some cases, the differences among the constructs have been emphasized more than the similarities, resulting in a fragmented literature and disjointed understanding of the factors that enhance or contribute to FBL.

The FBL construct needs further synthesis and explication and multiple research streams need to be integrated. In addition, there is not a useful theoretical foundation with which to guide research on how training can be used to stimulate FBL. Clarifying the construct, specifying the underlying theory, developing a battery of new measures, and articulating research hypotheses should lead to significant advancements in our basic understanding and enable a stream of meaningful basic research to test and refine the theory.

In an effort to fill this theoretical gap, we propose an integrated model of Training to Accelerate FBL (see Figure 1, next page). Our model is driven by the premise that training characteristics can be employed to promote FBL behaviors and outcomes, and that training design can be informed through a field-based learning analysis that considers both personal (trainee) and situational (field) characteristics. The theoretical foundation of this work is interactionism and based on the long accepted axiom in psychology that behavior (B) is a function of the Person (P) and the Situation (S), namely: $B = f(P, S)$. Not only is the individual's behavior influenced by significant features of the situations he or she encounters, but the person, who may even select some of the situations in which he or she performs, affects elements of the situation.

Research Approach

The research will proceed through three stages. In year one, the focus is on integration, conceptual development, and theory building; in year two, the effort will advance to correlational research examining key variables, and will include the development of new measures; and in year three, we plan to advance to quasi-experimental testing of research hypotheses.

The research objectives are to build and test an integrative model of training to accelerate field-based learning. We will synthesize and integrate existing research to provide a strong theoretical foundation; anchor theory in reality through interviews with experienced trainers and trainees; and test the theory with a series of research investigations that move from meta-analytic review to multi-level correlational study to quasi-experimental designs.

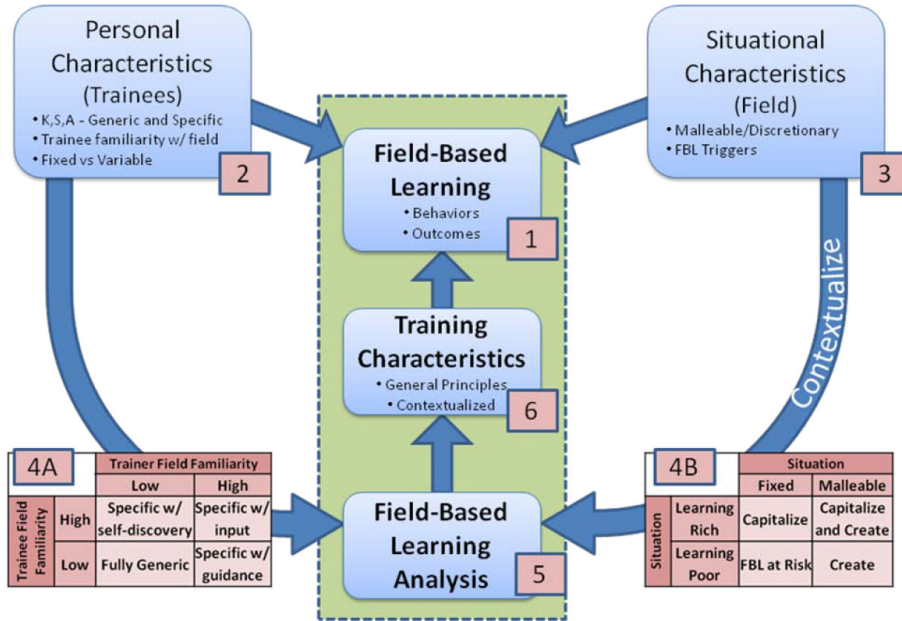


Figure 1. Training to accelerate field-based learning

Future Plans

During the remainder of year one, we will synthesize and integrate the disparate literature to further refine and detail how FBL relates to, but is different from, similar concepts in the literature (e.g., apprenticeship, mentoring, transfer-of-training). In this fashion we will outline the construct space and nomological network surrounding FBL and will also identify key individual differences and elements of work environments that promote FBL. Should there be sufficient data available, we will also perform meta-analyses as part of this review.

We will also conduct a series of interviews with a sample of trainers and trainees from a wide variety of occupations and organizational settings to ground the research in real-world needs, clarify the most salient and malleable personal and training characteristics that influence subsequent FBL, uncover key FBL learning “triggers,” and help us refine our propositions into testable hypotheses. We will be actively seeking to identify interviewees, in particular military and non-military training experts who are familiar with what trainees experience post-training and individuals who have a reputation as good “field learners.”

The ultimate goal of this effort is to yield innovative advancements such as new training needs analysis methods, instructional design principles, and training techniques designed to accelerate field-based learning, which could be integrated into a wide range of Army training programs for Soldiers and leaders.

Potential Army/Military Applications

It is imperative that we maximize and accelerate on-going learning in the field. This program of research is designed to address that need by uncovering ways of using pre-mission training to not only build skills but to catalyze and accelerate learning in the field. Simply put, this effort seeks to maximize the extent to which training prepares soldiers and leaders to learn during their subsequent field assignments.

Should the research program prove fruitful, the long-term benefits of this stream of work could be quite impactful. Eventually, this line of research could yield fundamental, innovative advancements in how the Army views learning, assesses training needs, delivers training, and promotes field-based learning. New training needs analysis methods, instructional design principles, and training techniques designed to accelerate field-based learning could be employed across a wide range of Army training programs for Soldiers and Leaders, and would also be applicable in many non-military settings.

An additional potential benefit of this way of thinking about training is that it would inherently increase the connection between schoolhouse training and field learning, (beyond current considerations of transfer-of-trained skills), which has numerous advantages.



Exploring the Use of Visual Features and Recognition Strategies in Perceptual Expertise

Contract #: W5J9CQ-11-C-0047

Contract Dates: 09/27/2011 – 03/01/2016

PI: Lisa S. Scott

Institution: University of Massachusetts Amherst

Co-PIs/Subcontractors: Tim Curran, University of Colorado

Jim Tanaka, University of Victoria

Although a great deal of scientific effort has been devoted to understanding the behavioral, cognitive and neural characteristics of perceptual experts, we know little about the diagnostic information and strategies that they employ to make fast, precise recognition decisions. This research furthers our understanding of the acquisition of perceptual expertise in object domains - many of which are vital in Army contexts such as recognizing threat-objects in the field quickly and accurately.

The defining quality of a perceptual expert is their keen ability to make fast, accurate identifications of objects from their domain of expertise at specific levels of categorization. The seasoned bird watcher, for example, quickly distinguishes a Nashville warbler from its close relative the Tennessee warbler. The car aficionado instantly knows the subtle differences between a 1955 Chevy Belaire from the 1956 model. Previous research suggests that expert object recognition involves a category shift in recognition from a basic level (e.g., bird, car) to more subordinate levels of abstraction (e.g., robin, Ford Escort).

Over the last decade, researchers have examined the skills of real-world bird, dog, and car experts and how their abilities differ from novices. Other work has examined the acquisition of perceptual expertise and the training protocols that promote expert recognition of objects from natural (birds), human-made (cars) and artificial categories.

Although a great deal of scientific effort has been devoted to understanding the behavioral,

cognitive and neural characteristics of perceptual experts, we know little about the diagnostic information and strategies that they employ to make fast, precise recognition decisions.

The central goal of this research is to identify the visual features and cognitive strategies of real world experts and to apply this knowledge for developing efficient protocols for training future experts.

Research Approach

We aim to identify the visual characteristics and perceptual strategies that real world experts bring to bear to recognize objects from their domain of specialization, and that can be emphasized during expertise training of novices.

Here, we propose that:

1. color and surface information,
2. high spatial frequency information, and
3. motion information are critical features use experts rely on for fast and accurate identification and recognition at the subordinate level.

Figure 1, next page, depicts our framework for examining the use of features and strategies in real-world and laboratory trained experts.

More specifically, this research has two main objectives:

Objective 1

The first objective of this project is to determine how real-world and laboratory-trained experts use the object features (including color, spatial frequency, and motion) when recognizing and identifying objects of within their domain of expertise. We hypothesize that relative to novices, experts will better allocate their attention to relevant stimulus features and dimensions and better differentiate among exemplars within their area of expertise at the subordinate and individual levels unless relevant features or dimensions are occluded or removed. Understanding the features that support expert performance will be important for designing efficient training programs.

Objective 2

The second objective of this project is to train novices to use similar strategies and features as experts. More specifically, the second objective is to establish a correspondence between real-world perceptual expertise and expertise that is acquired through directed laboratory training. We hypothesize that training that increases in difficulty, and emphasizes learning at more specific levels of abstraction, will lead to similar patterns of feature/dimension attention, tuning of sensory systems, and generalization of learning as found in real world experts. In addition, we plan to conduct an exploratory analysis of individual differences in efficacy of training relative to a pre-training baseline.



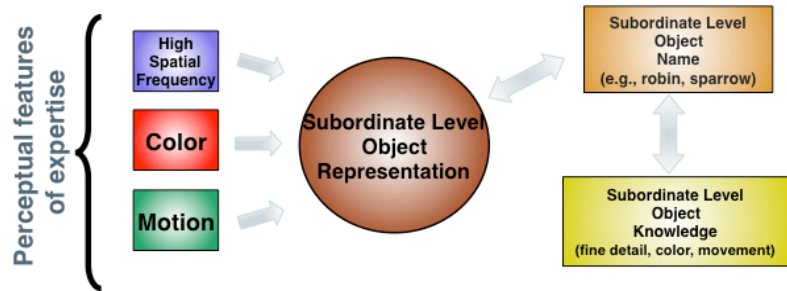
Accomplishments

We have begun the first phase of the research and are employing psychophysical methods to test how bird experts use color, spatial frequency and motion cues to facilitate their speeded recognitions (Experiments 1-4).

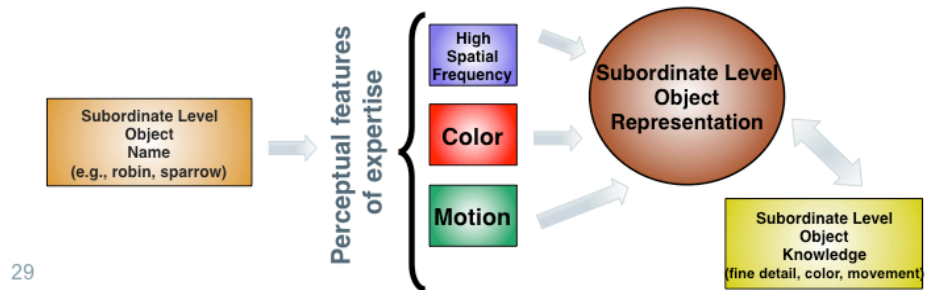
Experiment 1 was designed to examine whether expert and novice recognition is impaired when stimulus color information is manipulated or missing. To examine the role of color, we presented bird watchers (n=13, so far) and novices (n= 7, so far) with images of common birds (e.g., robin, sparrow) shown in congruent colors of the species, incongruent colors and monochrome (see Figure 2, right bottom).

We present category word (e.g., “Robin”), followed by a picture stimulus. Participants are asked to determine whether the picture matches the word category and are told to disregard color and recognize the birds based on shape. If the word and picture match, participants press the button labeled “same”; otherwise, they press the “different” button. The participants are asked to respond as quickly and as accurately as possible. The birds are presented in three forms: 1) congruent condition in which the color correctly matches the target bird species; 2) incongruent condition in which the color incorrectly matches the target bird species; and , 3) a baseline monochromatic condition in which the bird is presented in grey scale. We are interested in whether the type of color information (congruent, incongruent, monochromatic) influences the speed and accuracy of identification.

Assessing Real World Perceptual Expertise



Training Perceptual Expertise in the Lab



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Figure 1. (above) Models of Real World and Laboratory Trained Expertise

We propose the following models as foundations for examining real-world expertise and for training expertise in the laboratory. One difference between the real world and the lab training studies is the role of the subordinate label. For real world experts, the subordinate-level label is a behavioral marker of expertise and a downward shift in recognition. When training expertise, the subordinate-level label is a manipulation to encourage subjects to process objects at the more specific subordinate level. Recognition at the subordinate-level, likely requires that adults attend to features of an object with more detail than recognition at the basic level.

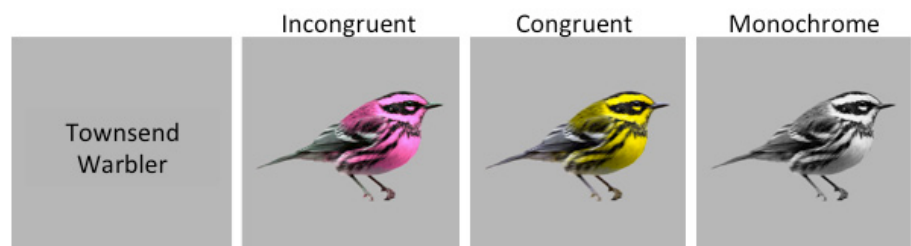


Figure 2. (above) Examples of Stimuli for Experiment 1b.

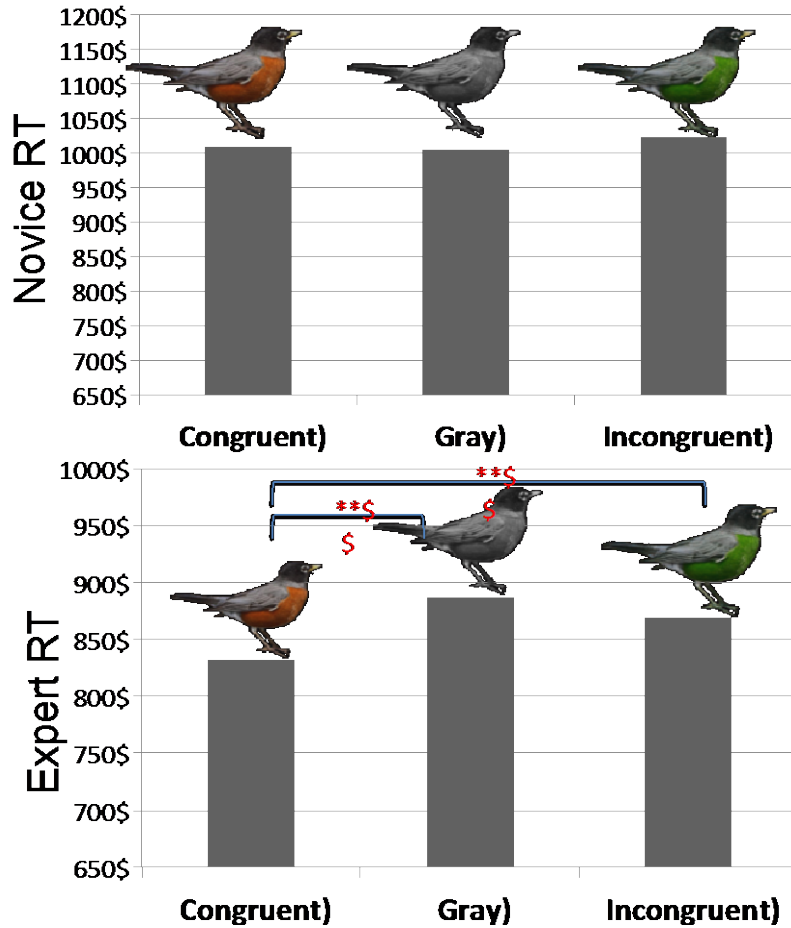


Figure 3. Reaction time results from Exp. 1a. Whereas novices do not show color advantages, bird experts show a reaction time advantage for correct color relative to grayscale and incorrect color. Asterisks refer to significant differences ($p < .001$).

In addition, experts also completed a more advanced bird identification task in which different species of Sparrows, Finches, and Warblers were used as stimuli. Expert participants completed the same task described above with several species within each of the above 3 families.

Preliminary results of Experiment 1a, in which the participants are asked to recognize birds at the subordinate level (e.g., “robin”), reveal that the bird experts are faster to identify birds when they are presented in their true color, compared to birds presented in incongruent colors and grayscale.

Interestingly, experts benefit from seeing birds in their true color when the label matches the image. However, when the label does not match the image, there are no differences across the color conditions. We hypothesize that this is because experts rely more on shape information when they reject the category label (e.g., Robin) and image (e.g., Cardinal) as being the same. In contrast, novices do not show a color effect. That is, they are equally as fast at recognizing the birds regardless of them being presented in their true color, incongruent color, or in grayscale (see Figure 3, above).

Even though we tell our participants that they should ignore color and recognize the birds based on shape, the experts are still influenced by color, while novices are not affected.

In Experiment 1b, in which we use more specific and advanced labels (e.g., nashville warbler), we again find the congruent color condition being faster than the incongruent color condition and the gray-scale condition. In other words, the experts benefit by having the birds presented in their true color. Specifically, experts benefit from seeing the birds in their true color relative to the grayscale condition, but not to the incongruent color condition.

This difference between Exp. 1a and Exp. 1b may be due to the fact that color, even though it is incongruent, helps the experts segregate the features of the bird. In the trials when the label does not match the image, experts are faster in the congruent color condition compared to the incongruent color condition, but not the gray-scale condition. We hypothesize that the reason why the congruent and the incongruent conditions are different, contrary to the finding of the Exp. 1a) could be because there is less shape difference between the label (e.g., townsend warbler) and the actual image (e.g., cape may warbler) and therefore more fine-grained analysis is required.

Overall, these preliminary results suggest that expert birders are faster at recognizing birds when they are presented in their true color. This suggests that color contributes to the fast and accurate recognition typical of expert birders. These results are consistent with our hypotheses; however caution should be applied when interpreting these results, as data collection is not yet completed.



Contributions to Basic Research

Visual perceptual expertise is critically important for a variety of professionals and has been investigated across a variety of domains. We are examining the specific visual features that adults focus on and the strategies they use as perceptual experts or while they become perceptual experts. The data from this project will allow us to learn more about how training changes performance on several tasks and whether or not this training changes neural responses. Identifying the diagnostic features and visual strategies used after training is important for designing effective training protocols for people in a variety of professions that require visual expertise (e.g. radiologists or TSA agents). Identifying the diagnostic features and visual strategies used by real world experts is crucial for designing effective training protocols in perceptual expertise. So far findings suggest that color is critically important for at least some forms of perceptual expertise.

Potential Army/Military Applications

We believe that perceptual learning and expertise hinges on the mind's ability to form object representations (in memory) that consist not only of elementary shape information, but also of more complex information such as color, motion, and texture. According to our reasoning, when an expert perceives an object of expertise, it is the rapid access to its robust object representation that facilitates the fast and accurate recognition of that object. Thus, in order to understand the acquisition of perceptual expertise, we must

learn more about the visual information that contribute to this enhanced object representation.

Although we use bird expertise as a model to understand the representation of objects of expertise, it is likely that the process of forming mental representations of other complex objects is similar. In other words, understanding the acquisition of bird expertise should further our understanding of the acquisition of perceptual expertise in other object domains - many of which that could be interesting in military applications. For instance, these findings show how military personnel can be trained to utilize multiple perceptual cues (e.g., color, shape) to become proficient at quickly and accurately recognizing threat-objects in the field. Thus, our goal is to identify the diagnostic features and visual strategies used by real world experts and to use that information to design effective training protocols in perceptual expertise.

Future Plans

In the next year we plan to complete data collection and analysis for Experiments 1 (color) and 2 (spatial frequency) and we plan to complete study design and training and begin testing for Experiments 3, 5, and 6.

Experiment 2 will present images that are filtered either for their high spatial frequency or low spatial frequency information will assess the importance of global shape and visual detail to expert recognition.

Experiment 3 will use point-light displays to examine the importance of motion in expert bird identification. The manipulations of color, spatial frequency and motion should yield important insights into the image properties that facilitate bird expertise. Identifying the

diagnostic features and visual strategies used by real world experts is crucial for designing effective training protocols in perceptual expertise.

Within the next year, we will begin training investigations (Experiments 5 and 6) that will allow us to track behavioral, ocular, and electrophysiological changes over the course of training and across different training conditions. These experiments should expand our understanding of the timing and magnitude of training effects, the contribution of different stimulus features, the generalization of expertise and the role of individual differences. We shall begin to employ EEG recordings and pattern classification techniques to predict the extent to which individual stimuli or categories of stimuli (e.g., bird species) have been learned and whether or not they have been learned in a manner that promotes generalization.

Associated Publications

Hagen, S., & Tanaka, J. (*in press*). Perceptual Learning and Expertise. In R. R. Hoffman, Hancock, A. P., Scerbo, M., Szalma, J. L., & Parasuraman R. (Eds). *Cambridge Handbook of Applied Perception Research*, Cambridge, U.K.



Effect of Threat on Task Performance

Contract #: W5J9CQ-12-C-0046

PI: Stephen G. Harkins

Contract Dates: 9/25/2012 to 9/24/2015

Institution: Northeastern University

Understanding how individuals perform when threatened is critical for the understanding and prediction of combat effectiveness of Soldiers. This research explores individuals' responses to different forms of threat and tests a model that predicts how the elevated "default" response under threatening conditions facilitates or debilitates performance. The results of this research may identify new methods of training that can be incorporated into combat training.

We perform many tasks in the presence of others. In some cases, their presence helps our performance, but in other cases it hinders it. This effect results from the fact that the presence of others arouses us, making it more likely that we will engage in the task behaviors that are most likely in the first place (a prepotent response). So, for example, expert pool players perform better when they are observed than when they are not, whereas novice players perform more poorly when observed. The most likely (prepotent) responses of the expert players are the correct ones, the presence of others produces arousal making these prepotent responses even more likely (potentiates them), and they perform better. However, for the novice players, the most likely (prepotent) responses are incorrect, and the arousal produced by the presence of others potentiates them, debilitating performance.

The Threat-Induced Potentiation of Prepotent Responses (TIPPR) Model argues that the presence of others simply represents one type of threat (e.g., these others may evaluate the performance unfavorably), and that any type of threat would produce the same potentiation of prepotent responses. For example, in a plane crash near Buffalo, newspaper accounts suggest that the wings were

icing and the plane began to stall. The plane was equipped with a "stick pusher," a computer-activated device that automatically uses the plane's elevators to put the nose down to regain speed so that the plane can come out of the stall. However, when the device engaged, the pilot did the "natural" thing and pulled the stick up, contributing to the crash. It takes a lot of training to learn to not pull up on the stick until the plane has regained enough speed to come out of the stall. The threat represented by the danger of the crash could have potentiated the prepotent, most likely, response, pulling back on the stick, possibly contributing to the crash.

In the course of carrying out their duties, Soldiers perform a wide variety of tasks under threat. The TIPPR Model suggests that when Soldiers face threat, the prepotent, or most likely, behavior on the given task will be potentiated (made more likely). If this prepotent response is correct, the threat will facilitate performance. However, if the prepotent response is incorrect and the Soldier does not recognize this, performance will be debilitated. On the other hand, if the Soldier is able to recognize that his or her prepotent tendencies are incorrect, and has the ability, motivation, and opportunity required for correction, performance will be facilitated.

Exploring the processes that mediate the effect of threat on task performance can lead to the design and implementation of behavioral programs aimed at improving the performance of Soldiers facing threat. To do so, in each of the contract years, we will conduct experiments that:

1. Test core claims of the TIPPR Model;
2. Test the model against a current alternative account, working memory deficit, which suggests that worries about the threat occupy processing capacity, thereby undermining performance; and
3. Extend the analysis from cognitive to a sensorimotor task, allowing comparison of the effect of threat on the performances of novices and experts on physical tasks.

Research Approach

In this research, we will conduct laboratory experiments using undergraduate participants. This type of work allows precise manipulation and measurement of the variables under examination, while the effects of extraneous variables are either controlled for or cancelled out as a result of random assignment. For example, we will use a virtual ball bouncing task in which participants are asked to stand in front of a large rear-projection screen holding a table-tennis racket. The participants' task is to use the physical racket to move a virtual racket to hit a virtual ball with the aim of minimizing the distance between the ball at the height of its trajectory and a target line over the course of a series of 40-second trials. On this task, we are able to measure virtually every aspect of the participants' ball bouncing behavior (e.g., racket acceleration, racket position and velocity, ball position and velocity).



Based on previous work, we know the prepotent response, hitting the ball with positive acceleration. Over trials, participants learn to perform the task well by hitting it with negative acceleration. We will randomly assign participants to either a threat or no threat condition, predicting that the threatened participants will perform more poorly than no threat participants because the former hit the ball with positive acceleration, the prepotent response. Thus, instead of simply manipulating the independent variable, threat, and seeing its effect on the dependent variable, accuracy in hitting the target line on each bounce, we will be able to examine each of the variables that mediate the performance outcomes.

In Year 1, we will also use experimental methods to test a core claim of the model by creating prepotent responses and showing that a social stressor potentiates them. In addition, we will pit the TIPPR Model against the working memory deficit explanation, using the test bed of mental horizontal subtraction problems.

Potential Army/ Military Applications

When carrying out their duties, soldiers must perform a variety of tasks while under threat. Knowing the effects that threat has on task performance is required for the design of effective behavioral training programs. However, the basic science in this area has not advanced to the point that it can inform efforts to design these programs. The current research advances our knowledge in this domain by continuing to develop an account, the TIPPR Model, which has shown promise in this regard. Although this work will help to resolve theoretical issues of long

standing, the amount of threat experienced on the battlefield exceeds what will be produced in our research. However, a wealth of research shows that the systems (HPA and SAM axes) that are impacted by our manipulations are the same systems that are activated in more threatening circumstances. Understanding the effect of threat on performance at the levels of threat allowed by Institutional Ethical Review Boards will provide the basis for understanding the effects of greater levels of threat on performance.

This approach would suggest that to predict the effect of threat on the performance of tasks ranging from mission planning to the operation of vehicles, communications equipment, and weapons systems, we must be able to identify the prepotent response tendency on the given task. On tasks that must be solved through logic, insight, or even intuition, identification of prepotent responses is essential to improve performance. Even on tasks on which performance can be improved by overtraining, without knowing exactly how performance unfolds, we cannot know what components of task performance should and should not be overtrained (i.e., made into prepotent responses). Some components of the training may facilitate performance, whereas others may have no or even a negative effect. In addition, understanding the architecture of performance makes it possible to modify not only the training, but also the equipment to take advantage of potentiated responses.

Future Plans

In the contract's second year we will conduct additional research that tests core claims of the model, specifically the claim that any type of threat will potentiate prepotent responses on a given task. Thus, we predict that a social threat that is completely unrelated to performance on the Graduate Record Exam quantitative test will produce the same pattern of effects as a threat that is related to performance on this test. This prediction is completely nonobvious, but follows directly from the TIPPR model.

We will also continue pitting the working memory account against the TIPPR Model using horizontal subtraction problems as the test bed. In Year 1, we extend our analysis from cognitive tasks to a physical, sensorimotor task, virtual ball bouncing with novices. In Year 2, we will extend this work to the performance of experts. Participants will be trained to an asymptotic level, and then the threat manipulation be implemented. Previous research suggests that when experts are threatened, performance can be debilitated. We will test this hypothesis using the virtual ball bouncing paradigm, which allows us to see in detail at exactly how any failure occurs.



LEADER DEVELOPMENT

DR. KARIN A. ORVIS, RESEARCH PORTFOLIO LEAD

As the Army reduces the number of personnel in the Service, fewer commissioned and non-commissioned officers will be represented at all levels of the Army. Yet, the Army has a constant need to retain the highest quality leaders, which necessitates an understanding of how to identify, develop, and retain quality leaders. Increased leader capabilities will also be required in order to be adaptive and resilient across the full range of operations (e.g., combat, stabilization missions). Leaders at all levels must possess the critical strategic thinking, command and sense-making, perceptual, and interpersonal skills to effectively lead and influence a variety of stakeholders both inside and outside the Army (e.g., both up and down the chain of command, interagency partners, local populations). Soldiers will also face increased time at home station compared to the last ten years, requiring an understanding of how leaders can best develop, mentor, and motivate their Soldiers in both the operational environment when deployed and at home station. In order to overcome such challenges, a systematic reevaluation concerning how the Army's leadership development process can optimize leader growth at a heightened pace is necessary.

The overarching goal of this research portfolio is to advance theoretical understanding of leadership and leadership development within the operational environment and at home station, and create leader development methods for maximizing the requisite cognitive, perceptual, and interpersonal skills for effective leadership across all levels of command.

Research objectives within this portfolio can be organized into three broad areas: (1) *leadership processes*, (2) *leader development*, and (3) *leadership assessment*.

Leadership Processes

ARI's Basic Research program seeks to develop theory and methods for identifying the requisite knowledge, skills, and abilities (e.g., critical strategic thinking, command and sense-making, perceptual, and interpersonal skills) that underlie effective leader influence. The program also strives to develop theory for understanding how leaders make rational, ethical decisions during both positive and negative emotionally-laden situations, as well as how they build a positive, ethical command climate to guide behavior of their subordinates.

Leader Development

The Basic Research program seeks to develop theory and methods for training the skills and behaviors necessary for leaders to effectively mentor and develop subordinates within both the operational environment and at home station, as well as methods for instantiating leader flexibility and adaptability in novel missions and operational environments, including how to quickly adapt and learn from both positive and negative on-the-job experiences. Identifying methods for developing strategic thinking and mission command skills in low to mid-level leaders, including the development of trust, cohesion, and shared cognition among subordinates, is also of top priority. Moreover, the program seeks to develop theory to understand the training and retention of quality leaders, including construct definition of high potential talent development programs and identification of the consequences of these development programs with regard to individual, work group, and organizational-level outcomes.

Leadership Assessment

ARI's Basic Research program strives to develop measurement techniques to objectively measure effective and ineffective, verbal and nonverbal leader behaviors.



LEADER DEVELOPMENT

DR. KARIN A. ORVIS, RESEARCH PORTFOLIO LEAD

Currently Funded Research

ARI's Basic Research program is currently funding three extramural research projects.

Brief descriptions of the contracts are provided below, with detailed research summaries of each contract provided on pages 33 – 38.

Specification of Effective Mentoring Behaviors for Leadership Competency Development and Adaptability

(W5J9CQ-12-C-0040; 2012-2014)

Dr. Lisa Finkelstein (Northern Illinois University) and colleagues' work investigates how mentors effectively enact common mentoring functions in order to shape mentees' competency development and other career outcomes, as well as how the effectiveness of specific mentor behaviors may depend on several contingency factors such as characteristics of the mentee and contextual factors.

Predicting and Enhancing Valued Outcomes Following Challenging Experiences: Toward New Individual Difference Measures and Induction Tools for Leadership Development

(W5J9CQ-12-C-0029; 2012-2016)

Dr. Todd Maurer (Georgia State University) is investigating developmental reflection as a key explanatory factor for understanding when leaders will learn and benefit from challenging on-the-job experiences. Specifically, this research seeks to empirically identify both predictors, such motivation and personality, and career/work outcomes associated with developmental reflection.

Emotion, Attentional Control, and Performance

(W5J9CQ-12-C-0035; 2012-2015)

Dr. Howard Weiss' (Georgia Institute of Technology) research focuses on how changes in individuals' emotional states at work influence daily variation in their subsequent attentional focus and job performance. Further, this research will investigate the moderating effects of leader behaviors and task characteristics, seeking to enhance understanding of how leaders can maximize subordinates' job performance.



Specification of Effective Mentoring Behaviors for Leadership Competency Development and Adaptability

Contract #: W5J9CQ-12-C-0040
PI: Lisa M. Finkelstein

Contract Dates: 09/26/2012 to 03/26/2014
Institution: Northern Illinois University

Co-PIs/Subcontractors: Kurt Kraiger, Colorado State University

Adaptability competency is particularly important in military contexts, as the types of problems faced by Soldiers in leadership positions change continually. Leadership development efforts, such as mentoring, that strategically capitalize on informal learning opportunities are particularly necessary. This project looks at how mentors enact common mentoring functions in pursuit of mentee development. Although research has been done to link mentors' mentoring functions (e.g., career support or psychosocial support) to mentees' career success outcomes, there has been virtually no examination of the most appropriate mentoring behaviors underlying these functions. Uncovering this information will help maximize the potential of ongoing mentoring relationships and inform training development for future mentors.

There is a growing need in civilian and military contexts to develop effective leaders who can adapt to quickly changing environments. Leadership development efforts, such as mentoring, that strategically capitalize on informal learning opportunities are particularly necessary. Mentoring is a developmental relationship between a more experienced mentor and a less experienced mentee or protégé. Recently, interest in fostering mentoring in organizations has increased. Evidence shows that good mentoring relationships can have positive outcomes for the organization and for the individuals involved, including mentee career advancement and other behavioral, attitudinal, health-related, relational, and motivational outcomes.

Although research has been done to link mentors' mentoring functions (e.g., career support or psychosocial support) to mentees' career success outcomes, there has been virtually no examination of the most appropriate mentoring behaviors underlying these functions. This lack of understanding of what good

mentoring looks like at the behavioral level limits our understanding of the mentoring process and our ability to properly identify and/or train mentors. There is need to know how mentor functions are enacted: what actually occurs between mentor and mentee? Are there specific behaviors that distinguish maximally effective mentors from marginally effective, ineffective, or harmful mentors?

Our project will look at how mentors enact common mentoring functions in pursuit of mentee development. The specific mentor behaviors selected and the particular ways that they are enacted are likely to depend on a variety of contingency factors, including the characteristics and goals of the mentee and the stage of the relationship. Organizational-level factors, such as the supportiveness of the climate and its effect on ongoing learning, are also likely to impact both the way mentors behave and the effect those behaviors have. Uncovering this information will help maximize the potential of ongoing mentoring relationships and inform training development for future mentors.

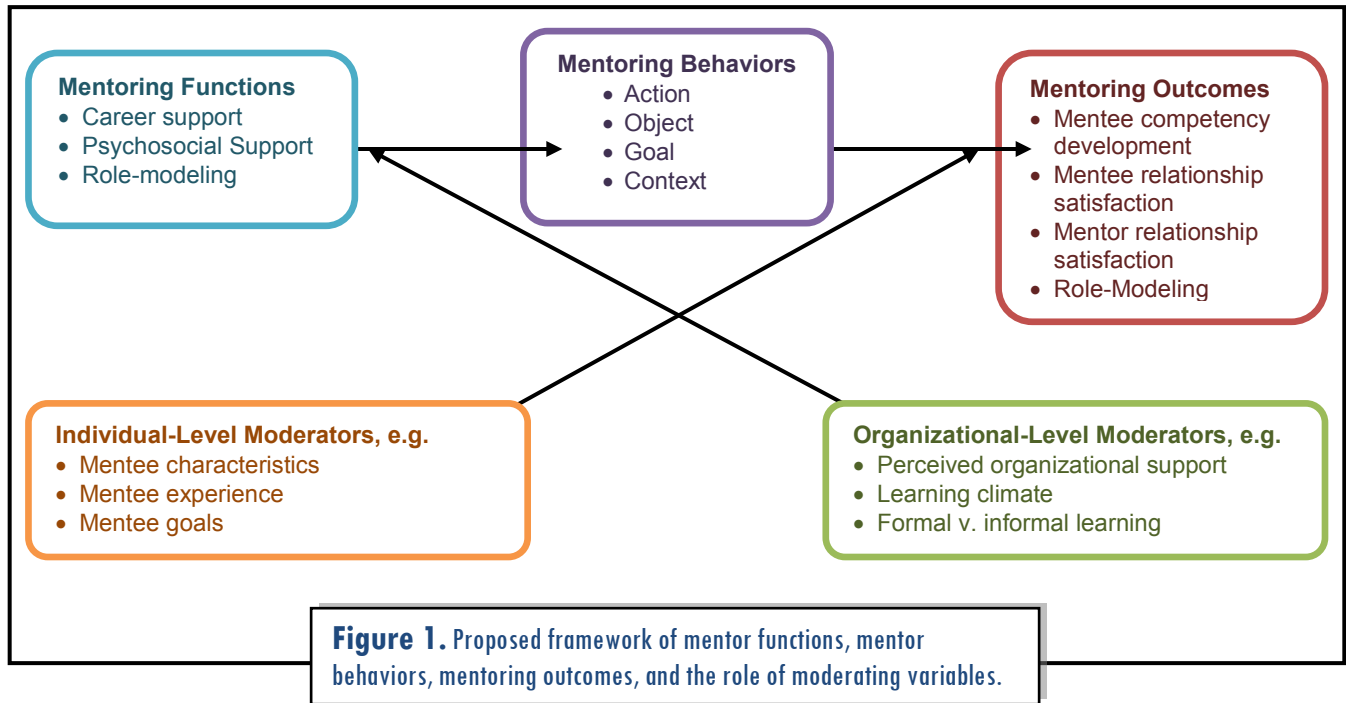
Research Approach

We will first identify experienced mentors and mentees across industries and conduct in-depth interviews. Interview responses will be coded and analyzed to derive a taxonomy of specific mentor behaviors and contingency factors. Subsequently, this taxonomy will be validated in an extensive survey of mentors and their mentees across multiple organizations. This survey research will empirically link mentor behaviors to mentoring outcomes (e.g., mentee satisfaction and competency development) while accounting for the effects of the contingency factors.

Potential Army/Military Applications

The development of effective leaders is an ongoing priority to the Army. Though formal classroom training is an important component of leadership development, informal learning opportunities are critical components to developing future leaders in the Army. In the Army, mentoring is often embedded in active duty assignments; it can occur between individuals of different rank or between peers and offers multiple opportunities for career support and building technical capacity beyond the chain of command.

To best support mentoring programs within the Army, it is important to know what constitutes effective mentoring. By building and validating a taxonomy of effective behaviors, the research can inform future interventions that directly benefit the Army and military in general. For example, potential mentors can be screened and selected on the basis of potential to engage in identified behaviors.



Additionally, mentor training programs and online support tools can be developed that are designed to facilitate development of effective mentor behaviors.

Finally, we intend to examine the effect of mentor behaviors on the development of various mentee competencies. We intend to include broad competencies generalizable to civilian and military leadership positions. One competency we intend to examine is the adaptability of the mentee in dynamic contexts. Researchers have suggested that mentoring, particularly through the provision of feedback, may possibly assist in the development of adaptability in the military, yet there are to date no empirical studies examining how mentor behaviors can foster the competency of adaptive performance. In the civilian world, adaptability performance is important; however, adaptability competency is particularly important in military contexts, as the types of problems faced by Soldiers in leadership positions change continually. These Soldiers are often called upon to make quick decisions

without the opportunity for additional consultation with a mentor.

Future Plans

During the next phase of research, we will conduct two literature reviews, develop a protocol for conducting interviews, and begin conducting interviews with expert mentors in multiple organizations.

The purpose of the first literature review is to facilitate development of protocols for interviews to begin later in the first year. In order to identify potential mentoring behaviors that can be incorporated into the interviews, we intend to re-examine relevant theory, research, and practice; and explore related areas such as education, coaching, and leadership.

The second literature review will be used to finalize outcomes to be measured in the second year of the project. We anticipate reviewing both the mentoring literature as well

as the relevant Army/military research to identify studies that examine either mentee competencies or dyad satisfaction with mentoring, as well as general competency models related to NCOs and junior officers in the Army.

Based on the literature review, a protocol for conducting interviews will be developed. These interviews will be semi-structured, allowing for inductive and deductive data gathering. We will design the interviews to probe mentors to describe what they do in behavioral terms, and to provide information on nuances and contingencies. We will also be targeting the interviews to elicit information regarding the connections between behaviors and the development of specific competencies.

Concurrent with the development of the interview protocols, we will be securing multiple sites for data collection. Using the interview protocol developed earlier in the year, we will then conduct a series of interviews with expert mentors in multiple organizations.



Predicting and Enhancing Valued Outcomes Following Challenging Experiences: Toward New Individual Difference Measures and Induction Tools for Leadership Development

Contract #: W5J9CQ-12-C-0029
PI: Todd J. Maurer

Contract Dates: 09/28/2012 to 09/27/2016
Institution: Georgia State University

Learning occurs as individuals engage in challenging experiences and then reflect on the outcomes of those experiences and plan for the future. However, the practice and phenomenon of developmental reflection is not fully understood. The present project will directly address the previously ignored role of reflection in relation to predictors and outcomes of learning. This research project will first develop and test a new measure and will then conduct a longitudinal study and a field experiment to examine the effects of a reflection induction/intervention designed to increase this behavior over time. The constructs and associated assessment methods developed in this project could be used as predictors of performance, motivation, development and adaptability in Army training and field settings.

Development of leadership abilities must come largely from within the person in response to the challenges that a Soldier and leader faces in the experiences he/she encounters. Researchers estimate that upward of 70% of all leadership development occurs through informal, on-the-job experiences. However, experiences, in and of themselves, do not lead to effective leadership development. In fact, one very important, yet little understood, intervening variable is reflection on the experiences - the thinking that occurs about the experience and related thoughts about future developmental actions. This intervening variable more directly shapes leaders' future use of such experiences.

In short, learning occurs as individuals engage in challenging experiences and then reflect on the outcomes of those experiences and plan for the future. However, the practice and phenomenon of developmental reflection is not fully understood. Prior research tends to minimize the underlying mechanisms explaining the effect of developmental experiences on subsequent outcomes (i.e., occurring in a virtual black box), instead of investigating the mechanisms directly. Below is a visual depiction of this assumption.



The present project will directly address reflection in some detail, examining it in relation to predictors and outcomes.

At the conclusion of this project we will have a number of new insights:

- This research will tell us more about reflection behavior: whether it constitutes an identifiable, distinct and somewhat stable individual difference variable; its content and dimensionality; and whether it can be induced, or whether it is both a stable and a malleable behavior.
- We will learn whether individual differences in reflection result in differences in development and other valuable outcomes over time (e.g., performance, job and career success, positive changes in leadership identity, turnover intentions and organizational commitment). In addition, as part of the test of whether we can increase this behavior experimentally, we will learn whether such an induction results in increased desirable outcomes over time in comparison to participants who receive no experimental induction.
- We will learn about the relationships between reflection and motivational, situational and other individual difference trait variables.



Research Approach

Ideally, the best research on the issues described above would be done longitudinally over time, using multi-source data or input of a respondent and his/her supervisor or coworker, in live or real world work settings, based upon sound theory and measures, and with both experimental and correlational (naturally observed relations) data.

The present research design will include two parts.

1. An effort to discover the nature of reflection by developing the new measure content and pilot testing these materials.
2. The main longitudinal study in which the new individual difference measures will be tested over time and in relation to other variables. This study will be a field experiment which also examines the effects of a reflection induction/intervention designed to increase this behavior over time.

Potential Army/Military Applications

The constructs and associated assessment methods developed in this project could be used as predictors of performance, motivation, development and adaptability in Army training and field settings.

Further, this project will develop and test an induction or intervention that can be used to increase reflection behavior, and subsequently influence valuable outcomes. While the project may be relevant to many of the areas of interest, it is especially relevant to *Leadership, Training and Learning, Human Resources*.

Leadership

The project will address critical aspects of leader skill development, and provide tested techniques for training leaders how to make the most of their development from challenging experiences they encounter. It will also enhance their own self-awareness of development needs and planning, providing strategies and measures that facilitate development and coping with novel performance situations and adaptivity.

In Army leadership development efforts, like institutional training, operational assignments are expected to be progressive and sequential, providing officers with opportunities to use and refine their skills and continue to learn through on-the-job experiences. This all points to the critical need for leaders to maximize development from experience via self-generated activities such as reflective practice, rather than classroom training, something the present project is designed to directly address.

Training and Learning

This project will be relevant to training design, including identifying training principles and theory that can be used to refine technologies.

The present project will involve principles from training, learning, cognitive processing, and motivation, including new tools and measures to enhance training and learning of Soldiers and Leaders. The Army of the future will receive less of its training in classroom style, and most of it in the field or on the go. The idea of drawing development from experience, as outlined in the present project, is very consistent with this theme.

Human Resources

By developing and validating new constructs and assessment methods that can be added to existing personnel and selection tools, the present study offers the potential for new techniques for identifying Soldier and Leaders who will be most effective at drawing the greatest development from challenging experiences they face on duty. These tools will be new, not previously examined in the research literature, and applied in a manner that will break new ground, offering not only scientific insight but also the potential for applied research and techniques. The project may aid in understanding the development and relationships among the psychological, demographic, motivational and organizational factors that might influence Soldier retention and Soldier productivity. By developing techniques and measures that relate to performance, development, success, satisfaction, commitment and turnover, the present study will be directly relevant to these key human resource concerns.

Future Plans

During the next year we will be developing measures of the reflection behavior. This task will include collecting free response question data about learning from challenging experiences from 75 employed business students (with leadership experience). We will conduct a pilot study of the newly-developed scales to test their initial psychometric characteristics among 500 online survey participants.



Emotion, Attentional Control, and Performance

Contract #: W5J9CQ-12-C-0035
PI: Howard M. Weiss

Contract Dates: 9/28/2012 – 9/28/2015
Institution: Georgia Institute of Technology

A Soldier's life, work life in general, is rife with emotional experiences and it is obvious that these emotional experiences can influence critical performance. The present research addresses the assumption that the same general regulatory resources control emotions and attention. Depletion of regulatory resources results in the misallocation of attentional resources necessary for work tasks. The purpose of this research is to determine how emotions affect daily variation in an individual's performance levels. Both the emotions themselves and the act of controlling emotions are expected to influence momentary performance levels within individual's workdays.

A Soldier's life, work life in general, is rife with emotional experiences and it is obvious that these emotional experiences can influence critical performance. Yet research on the effects of emotional states on performance remains fragmented. One such reason is that emotional states fluctuate, over days or even hours. Performance, however, has been conceptualized as a static concept, with an individual being a "good worker" or a "bad employee." In order to more fully understand the effect of emotions on performance, it is necessary to examine performance as a dynamic construct, which can change on a momentary basis. Instead of looking at one's overall performance, it must be acknowledged that individuals can have high performance days or low performance moments.

A basic and important assumption is that the control of emotions and the control of attention consume the same general regulatory resources. Consequently, the daily or chronic history of emotional control, not emotional expression without control, will lead to the depletion of individual resources needed to focus attention in the face of distractions

of any sort. Depletion of regulatory resources results in the misallocation of attentional resources necessary for work tasks. For example, a day full of emotional regulation will increase the likelihood of daydreaming, the inability to ignore noises, the frequency of surfing the web, etc.

The present research addresses such assumptions and is focused on discovering the interplay between changing emotional states and changes in performance levels that coincide with those states.

Specifically, the present research expects that strong emotions will pull an individual's attention off task, hindering performance as attention is redirected to the emotion. It is also expected that one's attempt to regulate emotions at work will deplete core individual resources; as more effort is expended to control emotions, more effort will be required to stay focused on one's current work tasks, as all effortful regulation draws upon the same limited pool. It is thus expected that as more effort is expended upon regulation, fewer resources will be available for work tasks and performance will suffer.

The purpose of this research is to determine how emotions affect daily variation in an individual's performance levels. Both the emotions themselves and the act of controlling emotions are expected to influence momentary performance levels within individual's work days. In addition, chronic depletion of regulatory resources is expected to adversely influence one's general ability to focus.

Research Approach

The set of studies involve daily surveys administered to full-time employees. Individuals will be prompted multiple times a day in regard to their emotional states, effort at controlling emotions, and momentary performance levels in order to understand the interrelationships of the variables. In addition, some supervisor reports of performance will be collected in order to validate self-reports of performance. Analyses will be conducted using multilevel modeling to account for the nested structure of the data and the repetition of surveys and measures. One study will also use lab tasks to measure attentional capabilities, both sustained attention tasks and inhibition or interference tasks, to determine if chronic depletion of resources relates to performance on tasks requiring attention.

Potential Army/Military Applications

Soldiers are faced with many different activities throughout the day. Variability in performance across those activities is obvious and important to understand. Some activities are such that one mistake, one instance of "below average performance" can mean the death of oneself and one's comrades. Here there is no



“average” performance, no ability to do better next time. Here we need to know what determines performance at a particular moment.

Environments in which these activities are done are not constant either. Distractions enter and leave the work context. Problems arise on both a predictable and random basis. New circumstances develop. Change is fundamental: changes in Soldier performance, changes in immediate environments, changes in demands, and, yes, changes in emotional states. In its Broad Agency Announcement, ARI explicitly states its interest in “understanding leading to the ability to predict how emotions, as positive and negative evaluative processes, influence actions and cognitions.” Implicit in this statement is the recognition that emotions, as states, constitute internal *changing* work contexts that influence performance in a direct and concurrent way.

The interest of the Army in the effects of emotional states on Soldier performance is entirely appropriate. Even the smallest amount of reflection will reveal that workplaces are settings of emotional intensity. If emotions are generated by appraisals of the reaching or impeding of important personal goals or values, then where is this more likely to play out than at work? Each day at work our needs, desires, and identities are challenged and affirmed. If this is true in the most ordinary civilian settings, it must be especially true in the military context, where “jobs” have life or death implications and where “occupations” are as much a calling as a simple economic exchange.

Our within-person approach encourages the development of process models for understanding affect-performance relationships and process models can be more useful for the development of interventions. The typical approach encourages static, structural models of associations. These can be useful approximations to what is going on, but affective states influence performance “on the ground,” in real time. Process models that study changes in the individual psychological mechanisms that accompany affective states will provide more proximal explanation. More proximal explanation will, in turn, allow for the development of novel, more precisely focused interventions.

The traditional approach to research linking emotions and performance contains an assumption that may not be appropriate for many military tasks. By looking at aggregate, average levels of performance the traditional approach assumes that specific instances of performance can compensate for each other, that a worker can compensate for one instance of poor performance with a subsequent instance of exceptional performance. But in many types of jobs, and particularly military tasks, this compensatory assumption is problematic. Each episode is self-contained. A Soldier defusing a bomb who, distracted by an emotional state, pulls the wrong wire cannot compensate by pulling the right wire the next time. There may not be a next time. Indeed, there may be many jobs in which failure at one time cannot be made up for with a series of later successes. Consequently, we need explanatory models that are better equipped to examine performance as it happens.

Future Plans

Within the upcoming year we will begin research to address the questions presented above. We will begin with a pilot study examining the episodic structure of performance. The intent of the pilot study is to determine that individuals can meaningfully identify and assess performance episodes. Performance episodes will be used in subsequent studies as a way of segmenting performance and tasks.

Once the pilot study is completed, we will begin work addressing the extent to which emotions pull attention away from one’s work during a performance episode. The focus will be on how emotions misdirect attention, hurting performance. It is expected that both positive and negative emotions will lead to the misallocation of attention.

We will also address the extent to which chronic depletion, or burnout, makes it more difficult to ignore distractions and remain focused on work tasks. It is predicted that higher levels of burnout will be related to poorer focus at work as well as poorer performance on tasks assessing general attentional capabilities.



ORGANIZATIONAL EFFECTIVENESS

DR. ANDREW J. SLAUGHTER, RESEARCH PORTFOLIO LEAD

In virtually all military operations and contexts, Soldiers and leaders work as part of a larger unit or organization. Units are currently operating in a Joint-Interagency context more than in the past, and this trend is expected to continue in the future. Combined and joint efforts by personnel from different services, agencies, and nations create numerous challenges, such as how understanding and assumptions of work processes will develop and be managed, and how organizational goals are defined. The fluid and often ambiguous environment of military operations demands that military personnel be able to rapidly adapt to changing circumstances. In order to achieve maximal effectiveness at all echelons, it is critical to understand how the processes, structure, and characteristics of these organizations impact performance.

The overarching goal of this research portfolio is to expand our knowledge of the complex social, cognitive and behavioral processes, structures, and characteristics of multi-echelon organizations, and to develop improved methods for identifying, measuring, and modeling these factors for predicting and improving organizational performance and effectiveness.

Research objectives within this portfolio can be organized into three broad areas:
(1) *organizational processes and dynamics*, (2) *multi-level methods and models*,
and (3) *organizational theory*.

Organizational Processes and Dynamic

ARI's Basic Research program seeks to develop theories of group structure and processes that can address cross-level influences, temporal variation and dynamics, and inter-organizational communication and collaboration. The program also strives to expand theory related to the transmission of meaning by individuals and collectives within and between organizations, building on theory related to organizational culture, organizational learning, social identity, social structure and sense-making.

Multi-level Methods and Models

The Basic Research program strives to develop new measurement techniques for assessing complex multilevel constructs that incorporate unobtrusive approaches and are useful for detecting and understanding variation in relevant timeframes. The program also strives to develop methods and models for analyzing types of organizational structure (formal and inherent) in order to understand how to achieve maximal organizational flexibility, effectiveness, and robustness in different mission contexts.

Organizational Theory

ARI's Basic Research program strives to develop a coherent multi-level theory of organizations interlinking macro-organizational characteristics, group processes and structure, social cognition, individual influence, and temporal dynamics. Developing and/or improving the tools, principles, and data used in the computational modeling of intra- and inter-organizational dynamics, such as agent-based modeling and other approaches to the analysis and study of dynamic systems, is also of top priority.



ORGANIZATIONAL EFFECTIVENESS

DR. ANDREW J. SLAUGHTER, RESEARCH PORTFOLIO LEAD

Currently Funded Research

ARI's Basic Research program is currently funding three extramural research projects.

Brief descriptions of the contracts are provided below, with detailed research summaries of each contract provided on pages 41 – 46.

The Co-Evolution of Multi-Dimensional Dynamic Networks of Multi-Team Systems Related to Organizational Effectiveness: Theory Development and Empirical Tests

(W5J9CQ-12-C-0017; 2012-2015)

Dr. Noshir Contractor (Northwestern University) and colleagues examine the co-evolutionary dynamics of cognitive, behavioral, and affective (emotion-related) networks in the contexts of multi-team systems (i.e., teams of teams). This research is designed to test specific hypotheses about group dynamics, as well as to explore new methods for defining and assessing relevant social networks.

Tracking and Shaping the Language of Working Groups

(W5J9CQ-12-C-0043; 2012-2014)

Dr. James Pennebaker (University of Texas, Austin) is using text-based methods to analyze the language (and associated linguistic properties) of small task-oriented workgroups. Specifically, this research seeks to assess basic social processes related to cohesion and informal leadership status via these novel measures, as well as use such measures to provide real-time feedback to individuals and groups.

Cadet Leadership Network Structures

(Joint USMA/ARI research; 2011-2013)

Dr. Kathryn Coronges (United States Military Academy) and Dr. Andrew Slaughter (ARI) are using social network analysis to study the characteristics of social networks involving trust and leadership perceptions among U.S. Military Cadets. Specifically, this research seeks to better understand the way in which individual differences (such as personality and key demographic variables), leadership behaviors, and military-related attitudes and values (including cynicism) relate to Cadet-reported trust and leadership relations among their peers.



The Co-Evolution of Multi-Dimensional Dynamic Networks of Multi-Team Systems Related to Organizational Effectiveness: Theory Development and Empirical Tests

Contract #: W5J9CQ-12-C-0017

Contract Dates: 08/20/2012 to 08/19/2015

PI: Noshir Contractor

Institution: Northwestern University

Co-PIs/Subcontractors: Leslie A. DeChurch, The Georgia Institute of Technology (Co-PI)
John E. Mathieu, University of Connecticut
Marshall Scott Poole, University of Illinois Urbana-Champaign

Many of today’s problems are too complex to be solved by individuals; they require people working together in teams within and across organizational structures. Complex military problems require organizational structures comprised of individuals. This research effort is developing and testing a novel theory of organizational effectiveness informed by multi-team systems theory and network theory, bringing together an interdisciplinary team with communication, psychology, and management scholars. This research also extends current network modeling techniques, and in doing so, enables the Army to understand collective functioning with a degree of accuracy substantially beyond what currently exists. Specifically, the findings of the project are relevant to three areas in need of knowledge within the Army: leadership, affect and emotions, and organizational effectiveness.

Many of today’s problems are too complex to be solved by individuals; they require people working together in teams within and across organizational structures. However, the emergent dynamics of these networked-organizational forms are not well understood and the problem is further complicated by the notion that very often multiple teams have to collaborate directly and interdependently in a so-called multi-team system (MTS). Existing organizational theories do not explain or predict the effectiveness of these teams and very few empirical studies exist in this domain to inform such theory.

The goal of this project is to develop and test a novel theory of organizational effectiveness informed by multi-team systems theory and network theory. This implies that *first*, organizations have to be recast as networked and goal driven collectives; and *second*, their performance is driven by three key socio-emotional properties: cognition, affect, and behavior. Taken together, these two perspectives proffer great potential in understanding organizational effectiveness as a function of patterned co-evolutionary networks comprised of dynamic multiplex and multilevel determinants (see figure 1, following page).

The project brings together an interdisciplinary team with communication, psychology, and management scholars in order to bring social network principles to bear on organizational theory. The project itself will be executed in three stages. In the first stage, the team will develop new theory explaining multi-team system function as multiplex, multilevel, dynamic networks and will develop the network algorithms to model these networks. In the second stage, archival data on multi-team systems will be used to develop the modeling scheme and indices to describe the networks and in the third stage the theories and analytics developing in the first stages will be used to study the role of leaders in teams to optimize multi-team systems.

Research Approach

The research has a highly fundamental nature and is aimed at the development of new theory. Based on existing theories from communication, psychology, and management, a new multi-team system network theory will be developed, based on the assumption that MTS function as networks. Models and algorithms will be developed to hypothesize and test these assumptions. Using existing data on MTS, the theory will be tested and further refined.

Potential Army/Military Applications

The research has relevance for the Army in two critical areas. First it helps in understanding the drivers of collective action and second it aids in developing the capacity to track the functioning of Army collectives in unobtrusive ways, at any point in time, and use the information to predict the effectiveness of units, teams and other collectives.



Most immediately, the findings of the project are relevant to three areas in need of knowledge within the Army: *Leadership, Affect and Emotions, and Organizational Effectiveness.*

Leadership

The project will provide knowledge on how leadership affects complex systems of teams. The framework developed in the study will be a starting point for applied research on leadership development and training within the Military.

Affect and Emotions

The theoretical and modeling efforts of this project will enable a deeper understanding of how the emotive, behavioral, and cognitive aspects of groups mutually influence one another and evolve over time. This will aid in the understanding of the impact of emotions on subsequent behavior, cognition, and behavior and will provide key insights in the role of emotions on team effectiveness.

Organizational Effectiveness

Assuming that teams and work in teams forms a key component of all modern organizations and especially the Army, insights into the effectiveness of teams is a prerequisite for military success. Furthermore, the research will aid in the development of leadership in complex and dynamic environment as well as team formation, especially for distributed or rapidly formed teams.

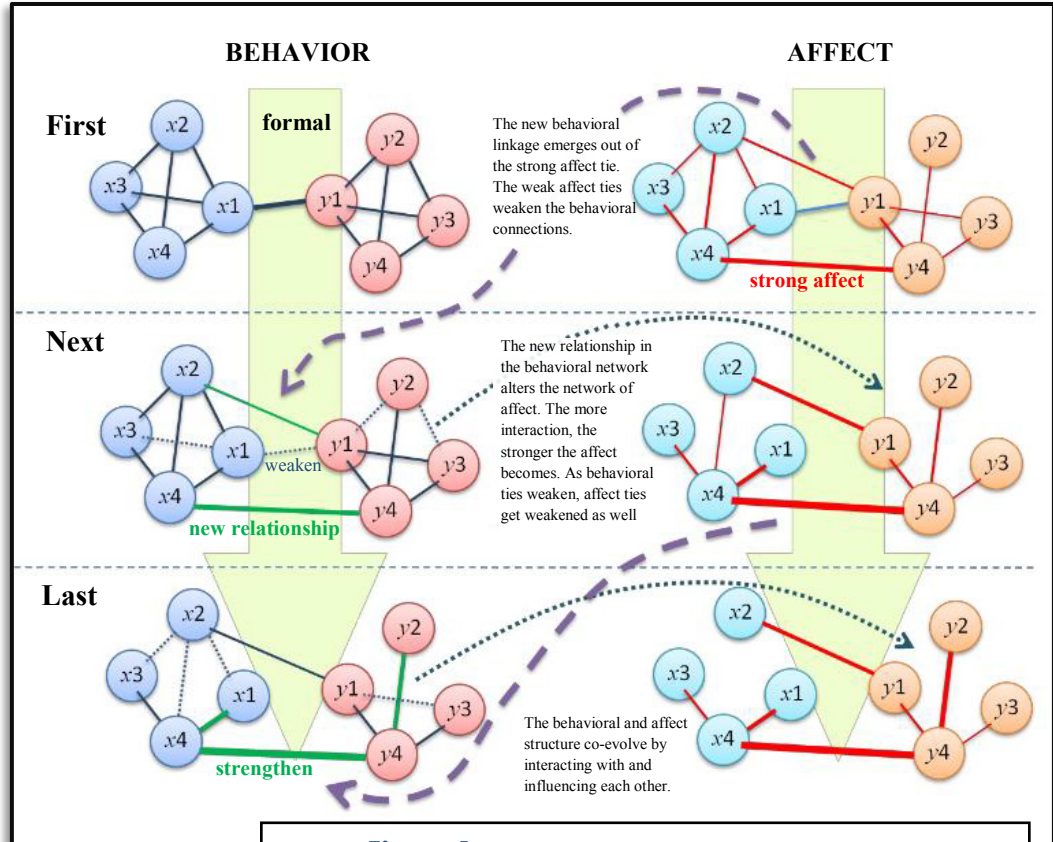


Figure 1. Co-Evolutionary Multi-Team System Networks

Organizational Effectiveness

Assuming that teams and work in teams forms a key component of all modern organizations and especially the Army, insights into the effectiveness of teams is a prerequisite for military success.

Furthermore, the research will aid in the development of leadership in complex and dynamic environment as well as team formation, especially for distributed or rapidly formed teams.

Future Plans

In the first year of this project, the team is devoted to develop a new theory explaining multi-team systems functioning as multiplex, multilevel, dynamic networks and will develop the network algorithms to model MTSs.



Tracking and Shaping the Language of Working Groups

Contract #: W5J9CQ-12-C-0043

PI: James W. Pennebaker

Contract Dates: 09/12/2012 to 09/12/2014

Institution: The University of Texas at Austin

Co-PIs/Subcontractors: David I. Beaver - The University of Texas at Austin
Arthur C. Graesser - The University of Memphis
Jeffrey T. Hancock - Cornell University

The purpose of this project is to apply a new way of thinking about language analysis to the understanding of the dynamics of online educational groups. Rather than focus on the content of group discussion, this research project measures words that reflect the essence of social relationships of people in the group. The current research is aimed at determining how features of natural language can measure actual group dynamics that are linked to solid outcomes – both in terms of learning and group performance as well as markers of group cohesiveness. Ultimately, the tools and algorithms coming from the project will have practical utility in the education and training of large groups of people.

Over the last 60 years, thousands of researchers from psychology, business, the military, education, communications, medicine, sports, and other disciplines have attempted to define what makes for successful group outcomes. The dominant paradigm that has emerged in the group literatures is the Input-Process-Outcome model (IPO). Most empirical studies focused on the Input portion of the model. Studies on group size, composition, role structure, context of the group, etc. have yielded an impressive number of findings that are often relevant for specific types of groups. By the same token, many studies have been done on group outcomes - ranging from measures of group performance, cohesiveness, longevity, etc.

The most discussed but the least studied or understood feature of the IPO model has been the P—process. There is no doubt that how members of a group work with one another is critical to understanding a group.

The problem has been how to measure group interactions. Three recurring issues have challenged group process researchers:

1. identifying the basic coordinating mechanisms of a working group,
2. agreeing on good measurement strategies that reflect relevant group processes, and
3. effectively manipulating the active ingredients in ways that can improve group processes and performance.

Researchers interested in social interactions are standing on the threshold of a new world. For the first time, scientists in social psychology, artificial intelligence, and communications are developing tools that can capture real-world social interaction through people’s use of natural language. We can now begin to think about ways of measuring information transfer, language coordination, emotional tone, and other processes as they occur and, at the same time,

distinguish which features of language are most related to outcomes of interest. Most exciting is that we can begin to harness these findings and provide immediate feedback to group members in ways that can shape their interaction styles.

We seek to track the natural language of working groups to predict and ultimately shape group cohesiveness and performance. Using an online group chat tool that we have recently developed, real-time assessments of word use will be made in online group interaction and will allow for real-time feedback in ways that are predicted to improve group functioning.

Research Approach

For the last several years, the PI has been teaching classes using a computerized technology for testing and for in-class discussions called TOWER (Texas Online World of Educational Research). The program allows for people to meet in online virtual groups of 2-30 people where they work together on assigned problems. At pre-specified intervals, each person’s typed words are analyzed by a word counting software, Linguistic Inquiry and Word Count (LIWC). In other words, the TOWER system allows for real-time analysis and feedback about the ways group members use words.

The fundamental goal is to harness the results of correlational studies to allow us to create feedback systems to influence later group behavior. While the idea of software to support group processes is not new, most group support technologies have not directly manipulated the ongoing communication processes of the group.



Potential Army/Military Applications

The purpose of this project is to apply a new way of thinking about language analysis to the understanding of the dynamics of online educational groups. The proposed approach represents a perspective that could not have been achieved even ten years ago. The central idea is to use computer-based language analysis methods to track ongoing group processes and to subsequently shape group behavior with real-time language feedback. Rather than focus on the content of group discussion, the proposed system measures words that reflect the essence of social relationships of people in the group. It is proposed that by monitoring and changing fundamental group processes that we can improve group effectiveness.

There is no doubt that how members of a group work with one another is critical to understanding a group. The problem has been how to measure group interactions. Three recurring issues have challenged group process researchers. Our online group monitoring and feedback tool will allow for a new generation of groups research in which interactions are studied in real-time. However, without the groundwork to systematically determine the features of language that are theoretically and empirically linked to social processes, the TOWER tool is just another communication medium. With the proposed studies, our goal is to develop a way of studying a wide array of online groups capable of providing feedback that influences communication, group dynamics, and group performance.

The studies in this contract focus on educational groups intended to improve learning, performance, and group climate. In reality, the underlying approach has relevance to any online group setting, including interviews, workplace meetings, training sessions, or even under stressful combat situations.

The current research is aimed at determining how features of natural language can measure actual group dynamics that are linked to solid outcomes – both in terms of learning and group performance as well as markers of group cohesiveness. More important, we hope to evaluate the degree that we can train people to work more effectively with one another in real-time using an efficient and automated set of language analysis tools. This project can help to uncover the degree to which certain types of tasks will benefit from greater rapport, positivity, information transfer, or even discrepancies in speaking turns or status between group members.

Future Plans

The promise of computerized technologies for the analysis of natural language use in real-time social interactions is in its infancy. The realization of text analyses for the measurement of ongoing social dynamics requires that several lines of research come together: establishing reliable and valid language-based metrics of group dynamics, using the language-based metrics to develop meaningful feedback systems to influence group processes, and the development of text analytic tools and approaches.

Across the three years, the primary focus of the research will be in educational settings where the goal is to maximize the individual performance of group members. Across all studies, we plan to collect two broad outcomes: group performance and self-rated group climate measures.

The first project is correlational; it will explore the relationships between word use within group interactions and various individual and group outcomes. The second project will rely on an automated system using algorithms derived from the first project wherein we will provide real-time feedback to individual group members and to the group as a whole about their social processes in an attempt to train groups to work more effectively.

By building on our research that examines the links between word use and social processes, alternative theoretical models of group dynamics will be tested, with an eye to developing interventions to assess and improve interactions. Ultimately, the tools and algorithms coming from the project will have practical utility in the education and training of large groups of people. Finally, we will continue building a new set of automated text analysis tools to track real world social behavior through people's natural language.



Cadet Leadership Network Structures (CLENS)

PI: Kate Coronges

Institution: The United States Military Academy

In Army settings, many types of interpersonal relationships are potentially important; they often lead to friendships, trusts, and perceptions of leadership. This research utilizes social network analysis (SNA) to explore patterns of friendship, trust, and leadership perceptions in a military context in order to identify the extent to which these networks can be described by particular social structures and individual characteristics, and to study the way in which these relationships relate to individual behaviors, cognition, and attributes. In terms of the social networks, initial analyses have found that there are significant correlations between dyadic ratings of trust, friendship, and leadership potential.

In most operational contexts, individual cognitions, behaviors, and emotions do not exist in a vacuum. Rather, individual characteristics are embedded in larger social systems – defined in part by complex patterns of formal and informal social interactions that exist among individuals and groups.

The structure of these relationships can affect things like the way that information flows through a group, and how individual affect and behaviors affect those around them. Similarly, the specific characteristics associated with particular individuals and groups can affect the way that such social systems are likely to manifest. Thus, to more completely understand a given social system, approaches are required that are capable of handling both individual and relational data with highly complex patterns of interdependence.

Increasingly, such research has been approached using the framework of social network analysis (SNA). Social network analysis is an analytical perspective and a family of research methods geared towards the study of relationships in larger social systems. Such techniques allow researchers to quantify key

aspects of a group’s relational structure, individual positions within that structure, and link such aspects to individual cognitions, behaviors, and characteristics.

In Army settings, many types of interpersonal relationships are potentially important. These include friendship, trust, and perceptions of leadership or leadership potential. Such relationships may be important for their own sake; however, they may also be important as predictors of individual and group outcomes within the larger social system.

The overall goal of the current research is to study patterns of friendship, trust, and leadership perceptions in a military context, to identify the extent to which these networks can be described by particular social structures and individual characteristics, and to study the way in which these relationships relate to individual behaviors, cognition, and attributes.

Research Approach

The current research collected data from 8 companies at a large military educational institution. These 8 companies

included 1048 individuals, with approximately 70% of individuals responding. Participants were each asked to identify up to five other people from their company that they considered to be their friends, who they trusted, and who they recognized as a potential leader. Each participant also completed a questionnaire designed to assess a number of different variables.

These measures include attitudes towards various Army-related values (including cynicism towards the organization), leadership style, motivation to lead, and various personality traits. Finally, individuals provided data on perceived cohesion in their group, the extent to which they identified with their organization and the larger Army, and their perceptions of shared leadership across the group. Several of these scales were developed for use in this study. For illustrative purposes, Figure 1 (next page) shows an example of the “leadership potential” network in one particular company.

To analyze the data, a number of techniques are being used. These include traditional descriptive and inferential statistics (e.g., regression), as well as more advanced techniques such as exponential random graph models (ERGMs).

Findings To Date

To date, analyses have been conducted to help validate the scales developed for this study (including cynicism towards the organization and endorsement of Army values), and to provide preliminary analyses of the structure of the interpersonal networks involved. Analyses show that the measure of organizational cynicism reflects a single underlying factor, while a preliminary analysis of the Army Values Scale developed for



this study suggest three underlying factors, reflecting respect for rules and Army values, high role-based performance expectations, and belief in the importance of the Constitution and the well-being of the Army.

In terms of the social networks, initial analyses have found that there are significant correlations between dyadic ratings of trust, friendship, and leadership potential. The data show that friendship is a significant predictor of interpersonal trust, with a mean correlation of $r = 0.41, p < 0.01$. Interpersonal trust is a significant predictor of perceived leadership potential ($r = 0.33, p < 0.01$). Finally, friendship is a significant predictor of leadership potential ratings ($r = 0.21, p < 0.01$).

Potential Army/ Military Applications

The current research should have implications for several areas of interest to the Army and the military in general. By integrating a structural/ relational perspective on trust and leadership, the study will provide a more system-level perspective on these important social relations. Rather than treating leadership perceptions or interpersonal trust as individual characteristics, this study will provide a better understanding of the relation between trust and leadership perceptions, taking into account the highly complex dependencies that may exist across multiple levels in the data.

The study will also shed more light on potential ways that informal social structures may be associated with important types of cognitions, such as attitudes towards the organization or the likelihood of endorsing certain values. This will provide an additional step towards understanding how to detect and define cultures and subcultures

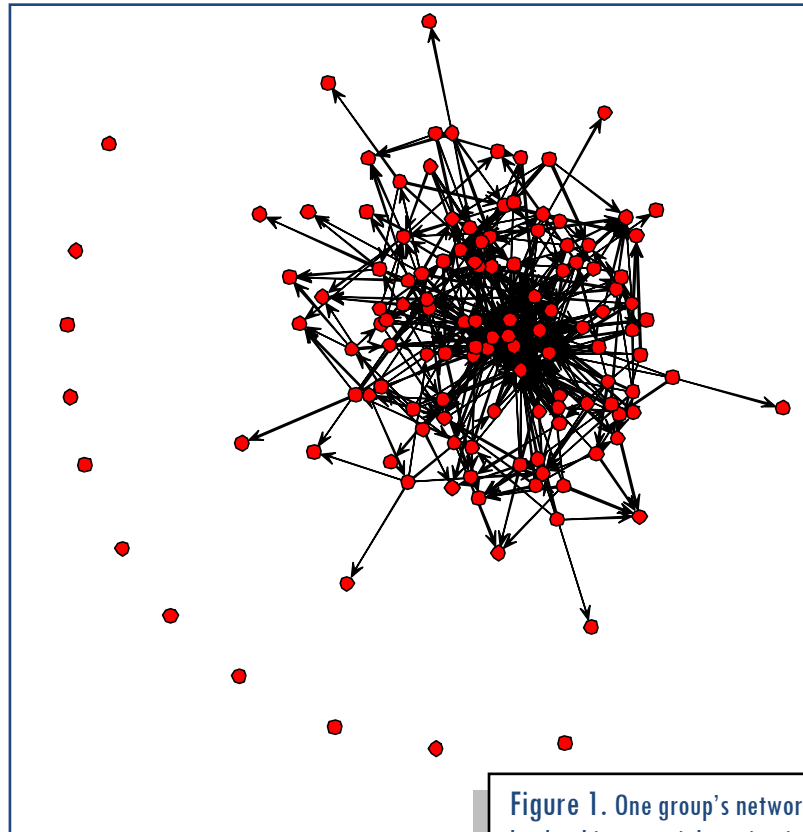


Figure 1. One group's network of leadership potential nominations.

within organizations, and how informal social relations impact the development of these cultures.

Future Plans

Data analyses using exponential random graph models (ERGMs) are currently ongoing. These models provide a powerful way to address research questions about structural patterns in social networks, and to combine them with research questions involving individual differences, behaviors, and cognitions. For example, they allow researchers to measure and statistically test the extent to which particular networks can be explained by certain basic social tendencies, such as the tendency to reciprocate certain types of ties; the tendency for individuals with certain characteristics or social positions to

send or receive different types of ties; the tendency for ties to form between people who have similar (or different) characteristics; and for individuals to group themselves into large or small cliques and clusters.

Using these methods, models are currently being constructed which should address several basic research questions about trust and perceptions of leadership potential in military networks: For example, how do individuals' leadership styles and motivation to lead relate to the extent to which they are seen as potential leaders by others, or see others as potential leaders? What are the structural characteristics that define the likelihood with which people are likely to be trusted, or to place trust in others? To what degree do these patterns of trust relate to individual differences, including personality or leadership?



SOCIO-CULTURAL CAPABILITIES

DR. ANDREW J. SLAUGHTER, RESEARCH PORTFOLIO LEAD

Army Soldiers and leaders are expected to plan and operate in ways that require them to interact with and support individuals from other military services, organizations (civilian and military), nations, and ethnic/cultural backgrounds. Understanding how differences in culture affect interpersonal interactions, social influence, leadership, and other social phenomena is critical to the operational effectiveness of the Army. Further, understanding how cultures develop and change will provide key insights into the broader context for these interpersonal interactions. The future success of Joint/Interagency and multinational operations is likely to be affected by the manner in which the underlying cultures differ, how those differences affect cognition and behavior, and the ability of individuals and organizations to recognize, plan for, and deal with these differences. In addition to the operational importance of cross-cultural capability, the Army is also interested in understanding and influencing the development and change of organizational culture within Army units and organizations. The Army's ability to assess and influence the organizational culture of units within the Army is one of the significant determinants of the Army's adaptability in a dynamic geo-political context.

The overarching goal of this research portfolio is to develop theories and models of culture that can be used to improve understanding and prediction of individual perceptions, cognition, and behavior within different cultural contexts, and to develop improved processes for assessing culture and culture-related behavior and cognition.

Research objectives within this portfolio can be organized into three broad areas:
(1) *defining and refining the meaning of culture*, (2) *understanding cultural differences in teams and groups*, and (3) *assessing culture and cultural change*.

Defining and Refining the Meaning of Culture

ARI's Basic Research program seeks to expand models of culture to fully incorporate perspectives offered by multiple disciplines (e.g., psychology, sociology, anthropology, behavioral economics, linguistics) to examine intra- and inter-cultural variability across a wider range of overlapping contexts, including geographic, organizational, social, and familial. The program also seeks to identify specific dimensions of culture applicable to ethnic, national, regional and organizational contexts, which can be meaningfully applied to improved understanding of individual or small group behavior and perceptions.

Understanding Cultural Differences in Teams and Groups

ARI's Basic Research program strives to develop an improved understanding of the antecedents of culturally-relevant cognition, such as cultural awareness and identity, as well as the psychological and behavioral reactions to violations of cultural norms, including cultural and individual differences that moderate such reactions. Developing theories to explain how or why real or perceived differences in culture (e.g., organizational, national) are associated with differences in relevant outcomes such as attitudes, cohesion, or performance is also of top priority.

Assessing Culture and Cultural Change

The Basic Research program strives to develop improved methods for assessing culture that integrate methods from psychology, sociology, ethnography, and anthropology. These methods should include or address concepts such as situational strength, cultural memes, cultural artifacts, norms, beliefs, and behaviors. The program also seeks to identify the sources of change in culture and enculturation across different time scales.



SOCIO-CULTURAL CAPABILITIES

DR. ANDREW J. SLAUGHTER, RESEARCH PORTFOLIO LEAD

Currently Funded Research

ARI's Basic Research program on socio-cultural capabilities is currently under active development.

We are currently seeking high impact research proposals to address one or more of the aforementioned research objectives.



The formal study of how social, psychological, and behavioral phenomena relate to physiological activity has existed for over 100 years. Recent advances in measurement technology, such as compact sensors resting on the skin surface to non-invasively record internal body functioning and neuroimaging devices to assess brain activity, and statistical approaches have led to a proliferation of research on the interrelationships of the human mind and body. This focus of this domain allows for the identification and understanding of what happens or exists inside the brain and body that gives rise to variations between people which lead others to label some individuals as ‘smart,’ ‘empathetic,’ ‘sociable’ or ‘extraverted’ among other characteristics. Further, fundamental research in the psychophysiological underpinnings of behavior and individual differences holds promise for making innovative strides in personnel testing, training, and leader development, specifically advancing the understanding of the underlying basis of why people think and behave differently. However, the great emergence of scientific potential from this discipline has not yet been fully harnessed by the Army, particularly in understanding and improving the cognitive and behavioral capabilities of the Soldier. Examining all key areas of significant promise is central to maximizing the usefulness of research from this domain.

The overarching goal of this research portfolio is to understand underlying dissimilarities in physiological activity that gives rise to observable individual differences in behavior and to identify useful biological responses as they relate to psychological constructs while advancing understanding of the theoretical framework linking physiological and cognitive processes.

Research objectives within this portfolio can be organized into two broad areas:

(1) *individual differences* and (2) *theory of the human mind*.

Individual Differences

ARI’s Basic Research program seeks to advance the fundamental understanding of physiological processes, both central (e.g., brain activity) and peripheral (e.g., muscle tension, heart rate), associated with distinct cognitive, affective, and motivational characteristics of individuals. The Basic Research program also strives to identify and/or explicate measureable biological and neurological correlates (emphasis on activity and function, not location) of psychological individual differences with the intent of improving the understanding of human behavior.

Theory of the Human Mind

The Basic Research program seeks to advance the theory of mind to elucidate the theoretical meaning of physiological activity from a psychological perspective, with particular emphasis on developing a broad theoretical framework connecting physiological function to psychological concepts (e.g., motivation, cognition, affect). The program also seeks to refine existing theory of individual differences (e.g., temperament, affect, ability, and aptitude) to link traditional psychological theory with the biological and neurological basis of individual variation, as well as explore the fundamental relationships among classes of individual differences.



Currently Funded Research

ARI's Basic Research program is currently funding four extramural research projects.

Brief descriptions of the contracts are provided below, with detailed research summaries of each contract provided on pages 51 – 58.

Constructing Emotion in the Human Brain: A Meta-Analytic Approach

(W5J9CQ-11-C-0046; 2011-2014)

Dr. Lisa Barrett (Northeastern University) and colleagues are meta-analytically combining findings across research studies found in the literature to identify data patterns that are stable and provide formal classification patterns of brain activity for emotional states.

Optimizing Threat Detection Under Signal-Borne Risk

(W5J9CQ-12-C-0028; 2012-2015)

Dr. Spencer Lynn (Northeastern University) uses a signal detection framework in a perceptual decision-making environment to assess how individual differences in affective reactivity, executive function, and motivation influence decision-making under conditions of uncertainty and risk.

Affective Realism: How Feelings Influence Perception

(W5J9CQ-12-C-0049; 2012-2015)

Dr. Lisa Barrett (Northeastern University) modifies conscious visual perception of individuals during experimental procedures to better understand first impressions and person-perception judgments; that is, how 'gut feelings' influence what individuals believe is true about a person or an object in the world.



Constructing Emotion in the Human Brain: A Meta-Analytic Approach

Contract #: W5J9CQ-11-C-0046

Contract Dates: 09/29/2011 to 09/28/2014

PI: Lisa Feldman Barrett

Institution: Northeastern University

Co-PIs/Subcontractors: Tor Wager, University of Colorado, Boulder

Emotions are at the core of how people make choices; without the guiding influence of emotion, people are often rendered incapable of acting upon even the simplest decisions. The research approach uses meta-analysis, which takes statistical measures from individual studies and statistically combines them to find the patterns that are stable. The successful harnessing of emotion can promote effective leadership, communication, mentoring, and training, as well as the overall mental and physical health of military personnel.

Emotions play a powerful role in our lives. They are at the root of how we make meaning and attribute significance to events, but they are also at the core of how people make choices—without the guiding influence of emotion, people are often rendered incapable of acting upon even the simplest decisions. Given the centrality of emotion to our lives, recent years have seen an explosion of research in affective neuroscience, which seeks to understand how emotional experiences are created by the brain.

Researchers have begun to use neuroimaging scanners, such as functional magnetic resonance imaging (fMRI) and positron emissions topography (PET), to monitor brain activity during emotional experiences. From 1990-1999, about 50 neuroimaging studies investigating the brain basis of emotion were published. Since 2000, that amount has nearly quadrupled, and continues to increase at an astounding rate each year. This research has the profound capacity to shed light on the neural mechanisms underlying our emotional lives. Using

neuroimaging, researchers can better understand how the brain creates the mind, and in so doing, understand how people experience emotions, how we regulate them, how they guide decision-making and inter-group relationships to help us get along and get ahead, and how individuals differ in the range and complexity of their emotional responses as well as their capacity to use them as a source of wisdom.

As powerful as neuroimaging is in its potential to shed light on the nature of emotion, it remains difficult to evaluate the cumulative findings of this still nascent approach. Individual neuroimaging studies often find different results because they use very small samples and vary considerably in their scientific rigor and methodological approaches. This poses a problem not only for the science of emotion, but it also poses a challenge for the Army, who could use neuroimaging findings to develop training tools, diagnostic tools, tactics, or policy.

Over the past 5 years, the Interdisciplinary Affective Science Lab at Northeastern University,

directed by Lisa Feldman Barrett, Ph.D. (in collaboration with Dr. Tor Wager’s lab at University of Colorado) has sought to rectify this growing problem by developing and applying statistical tools that can summarize and extrapolate from this mountain of studies what is true and consistent across them, so as to understand how the brain creates emotional states (e.g. Figure 1, following page).

Research Approach

The research approach uses meta-analysis, which takes statistical measures from individual studies and statistically combines them to find the patterns that are stable (see Figure 1 for an example of brain regions involved in emotion). Meta-analysis is the best known tool for identifying consistent brain correlates across laboratories and experimental tasks, and is uniquely capable of providing formal classifications for patterns of brain activity across a wide array of psychological states. The specific data-analytic approaches used were Multi Kernel Density Analysis, cluster analysis, and pattern classification.

Accomplishments

We began by updating our existing database of neuroimaging studies on emotion. The initial database included 233 studies extending from 1993 to 2007 to which we added an additional 164 studies extending from 2008 to 2011 for a total of 397 studies. This adds 70% more studies to the database. The updated database included a total of 914 contrasts assessing neural activity during affective and emotional experiences, and a total of 6827 participants across studies. Figure 1 illustrates the set of regions that respond most consistently during emotional states. Each study was

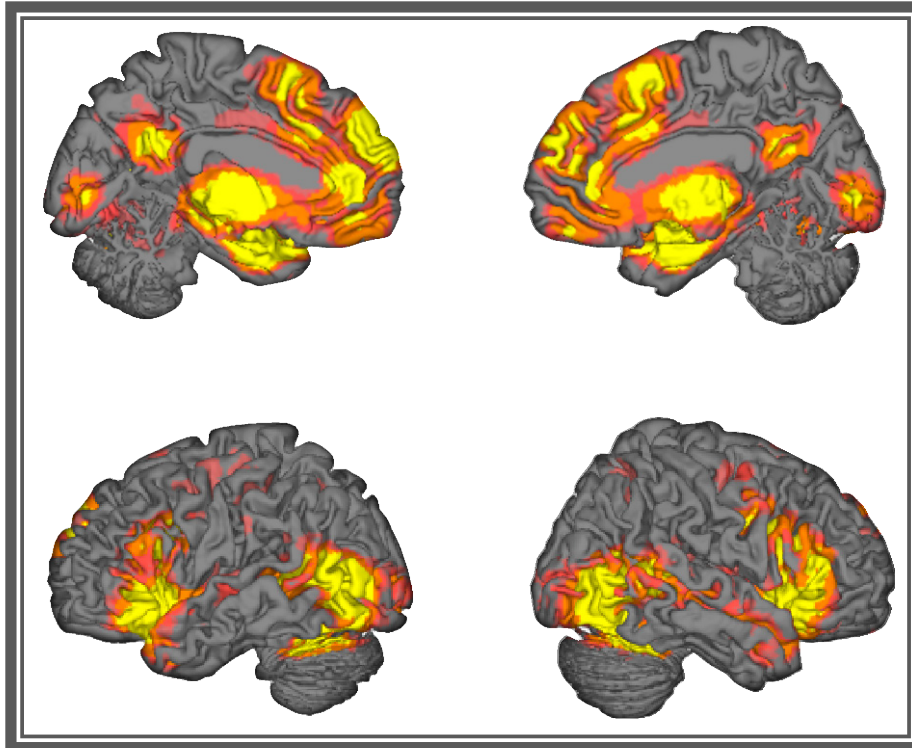


Figure 1. These are the brain regions that are consistently activated during the experience and perception of emotion. Top views are medial views of the brain (inside walls of the two hemispheres, with front of the brain towards the center); bottom views are lateral views of the brain. Yellow indicates a significant density of studies that show activation at these brain coordinates in a local neighborhood, and orange and pink indicate significant density using extent-based thresholding at primary thresholds of 0.001 and 0.01, respectively

read and meticulously coded for a series of variables (e.g., quality; whether or not participants were viewing images, listening to sounds, etc.; whether participants were experiencing emotions in themselves, or experiencing another person as having an emotion; etc.).

With this extensive database, we first tested the hypothesis of whether patterns of neural activation could be used to classify distinct emotional experiences, like anger versus fear versus happiness. For example we asked do studies of anger have some consistent pattern of activity that can be used as a “diagnostic pattern” for when a person is angry? Our results showed that it is possible to diagnose what emotion was being cultivated in a given study by a unique pattern of brain activity; using a novel Bayesian Cox cluster

process, we observed 67% accuracy in using neural activity to classify whether activations were related to ‘anger’, ‘fear’, ‘disgust’, ‘sadness’, or ‘happiness’ (chance being 20%).

Further analyses revealed that different emotions could not be localized to individual brain regions, or even to distinct networks, but rather the patterns of activity that diagnose an emotion are distributed widely across the brain. These results are the first step in developing brain-based biomarkers of different emotional states. They also indicate, however, that classical “basic emotion” views are not supported by brain data.

We further examined the brain bases for basic positive and negative feelings (Figure 2). One of the most important but unresolved questions

in the science of emotion is whether the same brain regions are involved in creating both pleasant and unpleasant states (i.e., that the brain contains one “workspace” for creating valenced feelings), or whether positive and negative feelings are computed in separate, distinct networks. Using our Multi Kernel Density Analysis, we identified an “affective workspace”, which consists of the amygdala, insula, ventral striatum, and several cortical areas that showed greater activity during both positive and negative affective states.

We also coded for other variables within the database for a variety of other components of emotional experience. Of note, we coded for whether affective states were elicited through various sensory modalities, for instance, through visual or

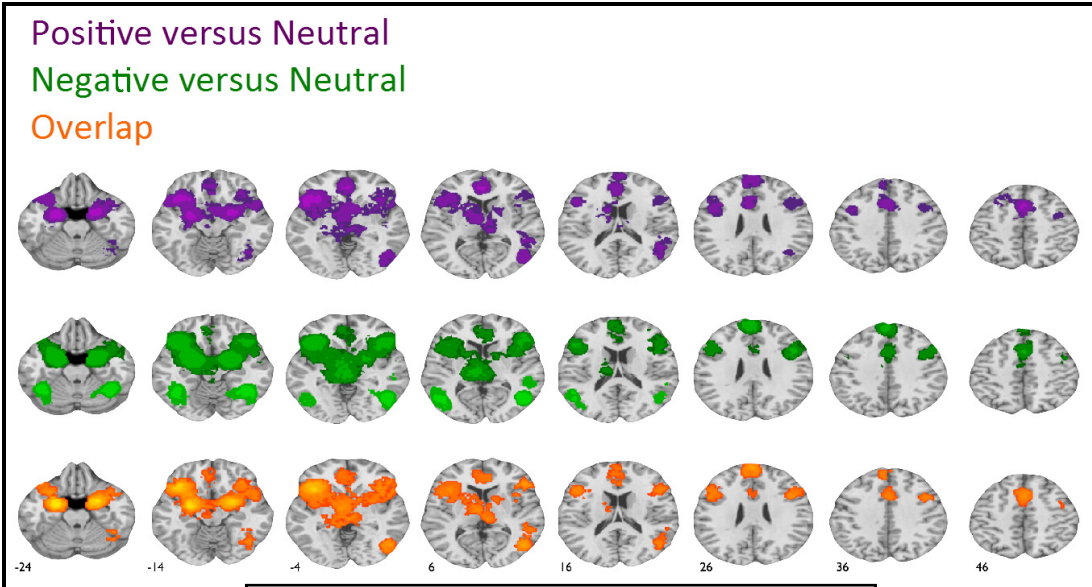


Figure 2. Overlap between brain regions that are consistently activated during pleasant and unpleasant states.

auditory channels, etc. We found that affective experiences commonly engaged the affective workspace, regardless of modality, but they also engaged cortical regions that are closely tied to each modality. For instance, when a person views a visual image that makes them feel negatively, there is an increase in activation in visual cortex when compared to neutral visual images; this means that visual cortex is responsive (either directly or indirectly) to the “affective potency” of visual information – if something has the potential to cause a bad feeling, visual processing is enhanced; a similar finding is true for auditory cortex as well. We were able to classify the modality through which affective experiences were evoked with an overall classification rate of 74% (chance = 25%) across visual, auditory, olfactory, and gustatory modes (there were an insufficient number of studies to examine emotions experienced through touch).

In a large scale collaborative effort, we are also comparing the results of our emotion database to a variety of

other domains including for language, attention, working memory, etc. Our goal here is to examine whether the brain contains a set of “common ingredients” that it uses to create emotions, perceptions, and cognitions – what we call “psychological primitives” – and whether these ingredients map to intrinsic brain networks.

Contributions to Basic Research

Despite over a hundred years worth of scientific inquiry, the underlying neurobiological processes that create emotions remains a mystery. However, research in human brain imaging is providing a pathway to address this question from a new angle, leading to a better understanding of the nature and function of emotion. A major advance of our approach is that it relies on the cumulative evidence of an entire field by using meta-analysis rather than forming conclusions on the basis of individual experiments alone.

The principal products of this research will be:

- The largest meta-analytic database of neuroimaging studies of emotion to date;
- Neural biomarkers created from conclusions regarding how specific emotional states are represented in the brain;
- A greater understanding regarding how basic psychological elements of emotions, such as positive and negative affect, are created in the brain; and
- Further support for and a potential unearthing of the domain-general functional architecture of the human brain.



Potential Army/Military Applications

The successful harnessing of emotion can promote effective leadership, communication (including persuasion and negotiation), mentoring, and training, as well as the overall mental and physical health of military personnel. By developing a better understanding of what emotions are and how they guide behavior, our findings have several important implications for the Army.

A major implication of this work is how it guides future work on emotion that is targeted for military applications. The research we conducted on the neuroscience of emotion indicates that many traditional theoretical views are insufficient for explaining the body of findings for what emotions are and how they operate. Military applications that are founded upon outdated theories of emotion are unlikely to yield fruitful outcomes. This work has pointed to new avenues for revealing what emotions are, what components and dimensions of emotions are respected by the brain, and thus, how to best harness emotions effectively for military applications.

This research takes the necessary steps towards developing a variety of specific applications of interest to the army. For the sake of brevity, one may consider this as a package of potential army applications or an ‘affective neuroscience toolkit for military applications’. In building this package, this research we conducted has examined whether brain activity can be used as biomarkers for different kinds of affective states. The research shows

that it can. To the extent that biomarkers for emotion can be

identified in an individualized manner, this research might also contribute downstream to the emotional assessment of soldiers, and improved matching of soldiers to the jobs that best fits their emotional profile and regulation abilities. Moreover, knowing something about the basic psychological ingredients of the mind would help to reveal which recipes contribute to optimal soldier and officer performance in a way that is not captured by standard psychological testing. Such research would have direct applications to understanding the psychological factors that contribute to recruitment, retention, and Army performance.

Future Plans

Developing a model of emotion that is grounded in neuroscience is the future direction of this work. Our future plans are to continue updating the database of emotion studies to include 2012 and beyond. Given the current acceleration of studies on affective neuroscience in the field, each year adds a much greater number of studies than the previous. Keeping on top of this growing volume of studies is a main priority. With this database, we will continue testing various hypotheses about the nature of emotion using Multilevel Kernel Density Analysis, pattern classification, and a family of cluster analyses.

Once we have established the validity of our biomarkers for emotion, we will examine individual differences in the brain bases of emotion. We will also use the results from the biomarker development analyses to predict the time-course of emotional experience within

individual participants during a new fMRI experiment.

This study will provide the first proof of principle that an individual person’s emotional experience can be predicted without collecting an extensive fMRI training dataset on that individual, and will provide evidence on the utility of the patterns of brain activity uncovered in the meta-analysis for understanding emotional experience.

Finally, we plan to expand and build upon these analyses by incorporating results from several meta-analyses conducted across a variety of other domains, including studies of memory, attention, reasoning, language, perception, and more. We are in the midst of pooling our emotion meta-analysis with a number of other meta-analyses obtained from our past work and from other groups.

Associated Publications

Barrett, L. F., & Satpute, A. (2013). Large-scale brain networks in affective and social neuroscience: Towards an integrative architecture of the human brain. *Current Opinion in Neurobiology*, 23, 1-12.

Lindquist, K., A., & Barrett, L. F. (2012). A functional architecture of the human brain: Insights from Emotion. *Trends in Cognitive Sciences*, 16, 533-540.



Optimizing Threat Detection Under Signal-Borne Risk

Contract #: W5J9CQ-12-C-0028
PI: Spencer Lynn

Contract Dates: 9/27/2012 to 9/26/2015
Institution: Northeastern University

Emotion perception research has revealed marked variability in people's abilities to infer emotional states of others. Using a novel utility-based signal detection framework, we will examine physiological, affective personality, and cognitive factors that contribute to this variability. The overall goal of this research is to determine how the individual differences contribute to effective perceptual decisions. The findings will provide information for selecting personnel who may perform well in particular contexts, and help identify decision-making vulnerabilities in Soldiers with the aim of providing training targeted towards specific perceptual weakness.

Emotion perception research has revealed marked variability in people's abilities to infer the emotional states of others. This variability is a function two factors: (1) the uncertainty and risk in the environment inherent to perception-- perceivers cannot be certain about what they are experiencing, and errors of perception may be costly; and (2) factors internal to individual perceivers--physical and psychological states and traits. Using a utility-based signal detection framework, this research examines how individual differences in affective reactivity, executive function, and motivation contribute to this variability in perception and decision-making, under conditions of changing environmental uncertainty and risk. The objective of the research is to characterize individual differences that influence perceivers' abilities to optimally adapt their emotion perception to changing levels of uncertainty and risk in the context of social stress.

Our objective is implemented via three specific aims

Aim 1 is to identify idiographic factors that influence the optimality of social threat perception. We hypothesize that physiological and

psychological factors influence people's ability to make effective perceptual decisions. Some of these factors may be state factors, such as anxiety or valence & arousal. Others may be trait factors, such as physiological response to stress, personality traits, and characteristics of executive function. The goal is to quantify how high or low "levels" of a specific set of individual differences either aid or interfere with optimal perception, in environments characterized by different levels of perceptual uncertainty and behavioral risk.

Aim 2 is to determine the computational mechanisms by which the individual difference factors exert their influence. We hypothesize that physiological and psychological factors affect perceptual decision making by influencing the accuracy with which the brain "estimates" three underlying environmental parameters that characterize the risk and uncertainty associated with decision-making. The goal is to quantify associations between individual difference factors and ability, or lack thereof, to adapt to changes in the three signal parameters that operationalize environmental uncertainty and risk.

Aim 3 is to use central neuro-physiological recordings (electroencephalography, EEG) to identify brain-activity correlates of perceptual decision optimization. We hypothesize that event related potentials (ERPs) and oscillatory patterns will be useful neuro-physiological markers for different aspects of performance on the task.

Research Approach

We operationalize risk and uncertainty in perceptual decision-making using signal detection theory's three environmental parameters (Figure 1, next page): perceptual similarity of targets and foils, relative base rate of targets vs. foils, and payoffs accrued for correct and incorrect response to targets and foils. These three parameters are implemented in an emotion perception experiment, in which perceivers categorize facial expressions that vary in intensity as. A mathematical model of signal detection uses values of the three parameters to predict how predict how perceivers should categorize the faces in order to maximize their net benefits accrued over a series of perceptual decisions.

We measure a number of individual differences across three domains of psychological function: affective reactivity (physiological markers of affective response to stress, stress reactivity, intensity of hedonic valence & subjective arousal), executive function (working memory capacity, awareness of task performance), and motivation (degree of approach vs. avoidance tendencies, the big five personality traits, and trait boredom proneness). Selection of these particular eight individual differences is motivated by a consideration of the specific operational characteristics of our perceptual decision task (e.g., utility maximization and operation under stress, uncertainty, and risk).

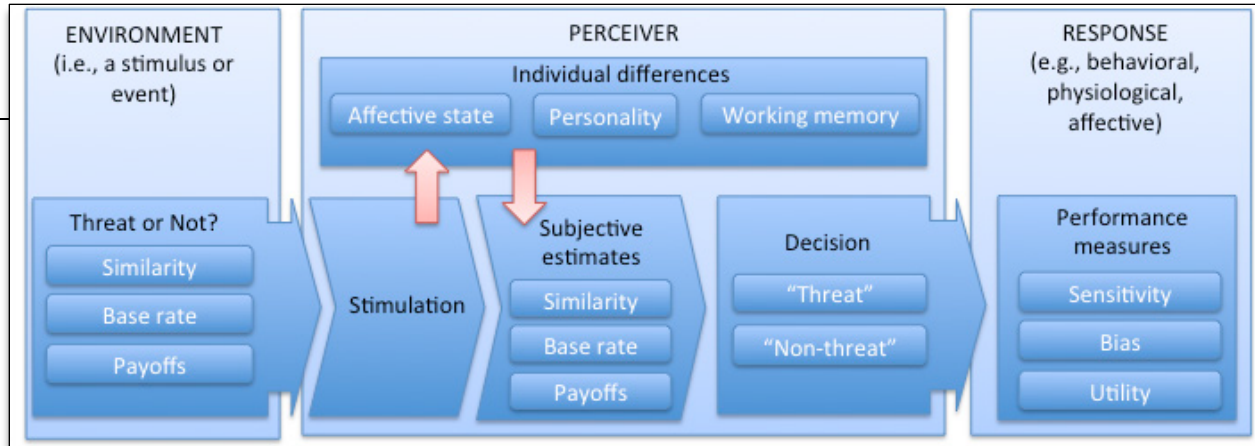


Figure 1. Threats in the world can be described by objective environmental parameters: their perceptual *similarity* to non-threats, the *base rate* of occurrence, and the *payoffs* (benefits and costs) for correctly or incorrectly recognizing them. To effectively recognize threats vs. non-threats, the brain must accurately estimate these environmental parameters. These subjective estimates are made through the lens of a perceiver’s individual characteristics (e.g., affective state, personality traits, etc.). Different characteristics may modulate or moderate the accuracy of subjective estimates, and thereby influence the optimality of perceptual decisions, measured as bias, sensitivity, and utility. In experiments, we measure individual characteristics as independent variables and use performance measures on threat detection tasks as dependent variables. Systematic experimental manipulation of the environmental parameters then permits us to infer how individual characteristics influence subjective “estimates” of specific parameters.

Potential Army/Military Applications

Findings will provide significant and useful information for:

1. Identifying social perception capabilities that will inform leader development;
2. Selecting personnel who perform well in particular contexts of decision risk and uncertainty; and,
3. Identifying decision-making vulnerabilities in Soldiers with the aim of providing training tailored to enhancing each Soldier’s perceptual-decision abilities, where low performance can be traced to an idiographic psychological state (e.g., enhanced affective reactivity) or trait (e.g., poor working memory capacity) or a source of environmental risk/uncertainty (e.g., poor sensitivity to changing base rates of threat).

Social/emotion perception is a component of effective leadership because leaders must foster cooperation with a variety of partners and appropriately read and influence a variety of stakeholders. This research will increase understanding of how nonverbal cues (i.e., facial actions) and environmental context (the risk and uncertainty inherent to perception of emotion) influence judgment of emotional intent. Our research will investigate novel methods to identify and assess emotion perception skills.

Effective perceptual decision making, whether in the realm of emotion, in social or physical threat perception, or in target detection and identification in the broadest sense, is critical to Soldiers and Officers alike. This research will increase understanding of how individual factors (e.g., affect & motivation, personality, executive function including self-awareness, and

appraisal of stress/anxiety) influence people’s ability to calibrate perceptions of the environment to appropriate action on those perceptions.

Though our research question is specifically applied to social emotion perception, our mathematical model of perceptual decision-making and our experimental design are readily generalizable to other domains of decision-making due to their foundation in a utility-based signal detection theory. Generalization of our framework to other domains of decision-making under uncertainty and risk therefore offers an additional avenue for future research and application.

Future Plans

This study will begin participant recruitment in January 2013. We will run 300 participants over the course of three years.



Affective Realism

Contract #: W5J9CQ-12-C-0049
PI: Lisa Feldman Barrett

Contract Dates: 9/18/2012 to 9/17/2015
Institution: Northeastern University

American Soldiers in contemporary combat or security situations face the vexing challenge of immediately identifying a threat when it is present, of determining whether another individual is friend or foe, and of determining quickly and efficiently whom they should trust and whom they should avoid. Research on effective realism allows us to explore (and eventually control for) the effect that gut feelings and quick judgments have upon events.

Food is delicious or distasteful. Paintings are beautiful or ugly. People are nice or mean. Perceptions of the world around us are always infused with positivity or negativity, or what is called “affective” meaning. Objects in the world are said to be “positive” or “negative” by virtue of their capacity to influence a person’s gut reactions. This is called “affective realism” – we believe something is true about a person or an object in the world because we feel it. Gut feelings can even cause people to “misperceive” objects, and might explain tragedies like the one that occurred in July 2007, when an American gunner aboard an Apache helicopter mistakenly killed a group of 11 unarmed people, including Reuters photojournalists, one of whom was carrying a camera (that was mistaken for a gun).

Can gut feelings help to explain, how a foe is mistaken for a friend, as when two American Soldiers were deliberately shot dead in Nineveh province by an Iraqi insurgent infiltrator whom the soldiers believed was a trustworthy ally?

Every day, Soldiers must make quick decisions about other people, whether they are embedded in a unit during wartime, on a peace keeping mission, negotiating in a cross-

cultural setting, or collaborating with unit members on a stateside base. Making a quick judgment of somebody else’s harmfulness, trustworthiness or competence in such settings is not a trivial example of person perception – such experiences have consequences for a soldier’s future mindset and actions, and often have consequences for somebody’s life.

Research Approach

To study affective realism, we use a method called “continuous flash suppression.” While sitting at a computer screen, a participant puts his or her head into a stereoscope (like at an ophthalmologist’s office). We flash changing visual images (including a neutral face) to the participant’s dominant eye, and to the other eye we present a static (but evocative) image (see Figure 1, next page, for a depiction of a trial in continuous flash suppression experiment). Research has found that people only consciously see the flashing dynamic images; the static image remains unseen, suppressed from conscious awareness. Yet when the “unseen” image is negative, it changes the participant’s gut feeling in a negative way, leading them to make harsh

judgments of the consciously “seen” images (e.g., a neutral face will be judged as less trustworthy and competent). When the “unseen” image is positive, it changes the participant’s gut feeling in a positive way, leading them to make lenient judgments of the consciously “seen” images (e.g., a neutral face will be judged as more trustworthy and competent).

Potential Army/Military Applications

Exploring the influence of feelings on vision is highly relevant to the Army. American Soldiers in contemporary combat or security situations face the vexing challenge of immediately identifying a threat when it is present, of determining whether another individual is friend or foe, and of determining quickly and efficiently whom they should trust and whom they should avoid. Mistakes can have dire consequences. The human mind evolved in a social context, and affective feelings reflect properties of the mind that attune it to the threats and rewards inherent in social living at all levels. In the proposed experiments, we are largely focusing on first impressions and person-perception judgments because they are important to the day to day functioning of Soldiers.

The proposed research will investigate whether people with stronger affective reactions demonstrate more potent affective realism effects. Effectively assessing pertinent individual differences such as those relating to affective realism can help the Army to better match a Soldier to a particular kind of work, or determined who will benefit most from affective calibration training (making this work also potentially relevant to basic research interests to support training that increase

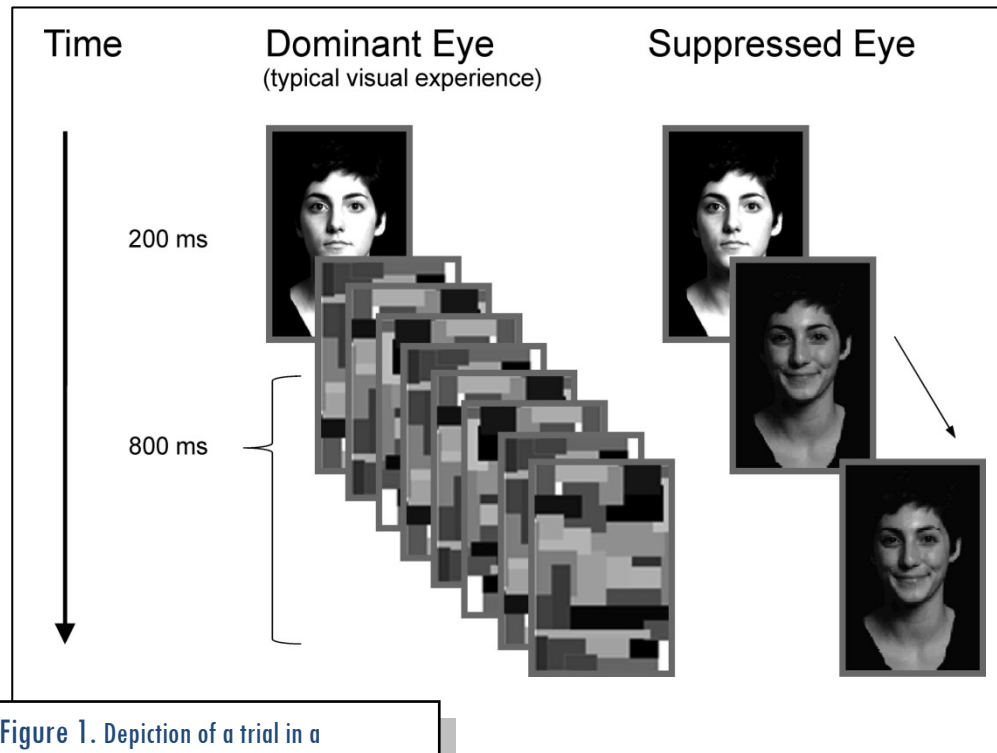


Figure 1. Depiction of a trial in a continuous flash suppression experiment.

The proposed research also has relevance for understanding the personal qualities that contribute to strong leadership in a complex and dynamic interpersonal environment. Being a good military leader means being able to read and influence the behavior of your troops. Individuals who are able to use their gut feelings to help them make decisions about Soldiers under their command, and to avoid this information when it is misleading, should be well suited as leaders. Good leaders know when their own affective reactions are a source of wisdom and information, and when such feelings might lead them astray.

The proposed research could also provide a foundation for the development of techniques to assess and foster self-awareness, so that individuals can become more aware of when they are using their affect to make judgments. If individuals are better able to detect when feeling is playing a role in their perceptions

and judgments, then they will be able to flexibly adjust their behavior. Aptly calibrating their feelings, and using feelings as a clue, signaling an optimal response, could help individuals to react more effectively in given situations, toward their comrades or enemies, or toward their superiors and subordinates, both under duress and in times of peace. Such self-awareness will enhance the soldier's ability to be more flexible and adaptable in novel situations that is critical to both the Soldier and unit's survival.

We hope it will also be possible to create a training program to teach Soldiers the optimal conditions for relying on their gut feelings. Such training not only has the potential to enhance survival, but likely will enhance the chances for success in missions that critically rely on social interactions, including negotiation, training, and the forming of alliances.

Future Plans

We will be conducting three experiments in the first year of the contract. First, we will study what causes the affective realism effect. We will confirm that unseen image produces physical reactions in the body that produce changes in gut feeling.

The second study will investigate whether gut feelings not only influence how we judge other people (e.g., is this person trustworthy?), but whether or not we literally SEE that person differently in a perceptual way (e.g., will a neutral face look slightly scowling?).

The third study will examine the scope of the affective realism effect (e.g., if you are feeling negative now, how long will it influence your perceptions in the future?)

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