

Foundational Research in Behavioral & Social Sciences: 2016 Summary



U.S. Army Research Institute
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Paratroopers from the 1st Battalion (Airborne) 143rd Infantry Regiment and Charlie Troop (LRS) 3rd Squadron, 124th Cavalry Regiment conduct airborne operations at Fort Hood's Rapido Drop Zone. U.S. Army photo by MAJ Randall Stillinger.

Foundational Research in Behavioral and Social Sciences: 2016 Summary

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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. Major themes throughout the basic research program include (a) advancing the science of psychological measurement, (b) understanding the influence of environmental context on behavior, and (c) integrating computational models and analytic approaches from other scientific disciplines into the study of organizational topics. These themes cut across the research portfolios.

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 develop improved processes for assessing culture and culture-related behavior and cognition.

Psychophysiology of Individual Differences

Understand underlying physiological dissimilarities that give rise to observable individual differences in behavior and identify useful biological correlates for psychological constructs with an emphasis on psychological primitives, while advancing understanding of the theoretical framework linking internal body functions to cognitive processes.

Research Program Structure and 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 Foundational Science Research Unit (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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TABLE OF CONTENTS

CONTENTS

	Page
PERSONNEL TESTING AND PERFORMANCE	1
Testing the Situational Strength Process Model: The Important Role of Motivational States	3
Predicting Success With Elementary Cognitive Tasks	7
Integrating Trait, Subjective Judgment, and Physiological Measures: Cognitive, Perceptual Speed, Psychomotor Performance and Sustained Operations	11
An Evaluation of Alternative g Tests	15
Individual Differences and Adaptive Flexibility: A Psychoneurometric Analysis	17
LEARNING IN FORMAL AND INFORMAL ENVIRONMENTS	21
Exploring the Use of Visual Features and Recognition Strategies in Perceptual Expertise	23
Training as a Catalyst for Field-Based Learning: An Integrated Theory, Principles, and Program of Research	27
The Effect of Threat on Task Performance: Testing the Threat-Induced Potentiation of Prepotent Responses Model.....	30
LEADER DEVELOPMENT	33
Specification of Effective Mentoring Behaviors for Leadership Competency Development and Adaptability	35
Emotion, Attentional Control, and Performance.....	38
Predicting and Enhancing Valued Outcomes Following Challenging Experiences: Toward New Individual Difference Measures and Induction Tools for Leadership Development.....	41
A 15-Year Extension to the Baseline Officer Longitudinal Development Study (BOLDS)	44



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CONTENTS (continued)

	Page
ORGANIZATIONAL EFFECTIVENESS	47
Tracking and Shaping the Language of Working Groups.....	49
Understanding Network Socio-Geographic Dynamics: Using Smartphones to Locate, Track, and Study Goal-Directed Team Behaviors	53
A Computational Modeling Approach to Organizational Effectiveness: Mapping the Effects of Leadership, Group Structure, and Environmental Shocks	65
The Development and Construct Validation of Unobtrusive Dynamic Measures of Team Processes and Emergent States	59
SOCIO-CULTURAL CAPABILITIES	63
The Role of Implicit and Explicit Cognition in Cultural Learning.....	65
The Etiology and Consequences of Organizational Conflict Cultures	76
PSYCHOPHYSIOLOGY OF INDIVIDUAL DIFFERENCES	71
Optimizing Threat Detection Under Signal-Borne Risk.....	73
Affective Realism: How Feelings Influence Perception	77



PERSONNEL TESTING AND PERFORMANCE

DR. ANDREW J. SLAUGHTER, 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 to 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:
assessment methods, measurement theory, and 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.



PERSONNEL TESTING AND PERFORMANCE

DR. ANDREW J. SLAUGHTER, RESEARCH PORTFOLIO LEAD

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 3-19.

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

(W5J9CQ-12-C-0036; 2012–2017)

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; 2012–2015)

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.

Integrating Trait, Subjective Judgment, and Physiological Measures: Cognitive, Perceptual Speed, Psychomotor Performance and Sustained Operations

(W911NF-13- 1-0441; 2013-2017)

Dr. Phil Ackerman (Georgia Tech) is investigating individual performance, effort, and attention through the combined use of psychological traits (including traits associated with ability, personality, and motivation) and key physiological indicators of arousal, stress, emotional reactions, and activity.

An Evaluation of Alternative g Tests

(W911NF-13- 1-0353; 2013-2017)

Dr. Michael McDaniel (Work Skills First, Inc.) is testing the extent to which the dominance of a general factor of intelligence ("g") is associated with group differences in some of the psychometric characteristics, structure, and validity of these tests.

Individual Differences and Adaptive Flexibility: A Psychoneurometric Analysis

(W911NF-14- 1-0018; 2014-2019)

Dr. Christopher Patrick (Florida State University) is utilizing a multi-faceted conceptual and methodological approach to investigate the influence of key individual difference variables on adaptive flexibility, specifically boldness-fear and inhibition-disinhibition.



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

Contract #: W5J9CQ-12-C-0036

Contract Dates: 21 SEP 2012 – 26 SEP 2017

PI: Reeshad S. Dalal

Institution: George Mason University

Co-PIs/Subcontractors: Rustin D. Meyer, Georgia Institute of Technology

Situational strength is defined as “implicit or explicit cues provided by external entities regarding the desirability of potential behaviors” (Meyer, Dalal, & Hermida, 2010, p. 122), and is believed to consist of four facets (i.e., clarity, consistency, constraints, and consequences; Meyer et al., 2010). The present study extends previous ARI-funded research through the development of a moderated-mediation process model that details the joint influences of situational strength and individual differences on motivational states and subsequent performance outcomes. This model is then extended into four areas of inquiry: (a) the relationship between situational strength and personality, motivational states, and performance; (b) the additive and multiplicative effects of situational strength emanating from multiple sources (e.g., supervisor) on goals, state affect, and task performance; (c) the emotional and behavioral reactions to both conscious and non-conscious forms of situational strength; and (d) the influence of situational strength on organizational citizenship behaviors and counterproductive behaviors. Combined, this research can inform applied research for selecting and classifying Soldiers to optimize performance.

Modern Soldiers operate in fluid environments that sometimes require personal discretion, yet other times require strict adherence to orders and/or rules of engagement. Unfortunately, psychologists have not yet reached a consensus regarding the effects of various environments on human behavior or even how to quantify environments’ key characteristics. Yet, one concept widely acknowledged as relevant to both these issues is “situational strength,” which is defined as the presence of implicit or explicit cues provided by external entities (e.g., leaders, colleagues, organizational policies) regarding the desirability of potential behaviors. Situational strength has been shown to have important effects on a variety of organizationally relevant behaviors and outcomes, including counterproductive (or deviant) work behavior, which is the focus of the present summary.

We empirically tested an unexpected finding from our previous ARI-funded research: namely, that individual differences are more strongly associated with counterproductive work behavior in strong than in weak situations (the opposite of what was expected on the basis of conventional situational strength theory).

Our primary argument was that employees are generally likely to show negative emotional responses to strong situations, thereby also increasing the likelihood that they will engage in counterproductive work behavior, but that this effect will be especially pronounced among those with an already deleterious trait profile (e.g., those with low levels of Conscientiousness and/or Agreeableness, those with antisocial tendencies).

This project has important implications for applied research in the context of modern warfare. For example, situa-

tional strength could serve as the foundation for a novel way of quantifying the momentary environments Soldiers experience. This information could then be used to better predict Soldiers’ likely emotional and behavioral reactions to these situations based on their underlying personality, thereby reducing deviant Soldier behaviors, while increasing Soldier productivity and “citizenship.” Said differently, this research is intended to facilitate sense-making across diverse environments, thereby helping the Army better understand how to select and classify Soldiers who are able to adapt and perform effectively.

Research Approach

Emotions are, by definition, fleeting. In order to understand emotions and their effects on individuals’ behaviors, researchers should therefore sample participants over time. As such, the present results are based on 2,307 observations collected from 67 full-time employees. Participants first completed a battery of tests designed to assess their demographic background, personality, and typical occupational environment. Then, for a period of 2 weeks, participants were asked five times per day to report on their immediate occupational environment, emotional experiences, and behaviors using either an iPod Touch device or their personal smartphone. This research design is especially well suited to the present research question and provides a level of specificity that is often not available using more commonly used research methods.

Accomplishments

Results of the present project reveal six key findings (see Figure 1 for a visual depiction). First, as anticipated, situational strength showed significant momentary fluctuations over the course of the observed 2-week period. This finding is a novel contribution in and of itself because previous research



has treated situational strength as a fixed characteristic of work environments. The presence of moment-to-moment variability, therefore, allows us to examine situational strength's potential connections with emotional experiences and specific subsequent behaviors.

Second, the personality traits of Conscientiousness (i.e., the extent to which someone is dutiful, industrious, and rule-oriented) and Agreeableness (i.e., the extent to which someone is cooperative, kind, and considerate) showed negative relationships with counterproductive work behavior, meaning that Conscientious and Agreeable employees were generally less likely to engage in instances of counterproductive work behavior than their low-Conscientiousness and low-Agreeableness counterparts. Although several previous studies have shown this effect, it is important to replicate it given the nature of the research methods used here.

Third, and consistent with our past ARI-funded research, strong situations led to increased counterproductive work behavior. This finding is especially important because it was the primary driver of the present project. Specifically, we sought to investigate the extent to which situational strength serves as a “double-edged sword” that simultaneously encourages task performance and citizenship behavior, but also encourages increased counterproductive work behavior.

Fourth, and directly relevant to the previous finding, another novel contribution of the present study is that situational strength correlated with state negative affect, such that employees reported greater levels of negative affect in strong situations compared to weak situations. This finding is particularly important because it may suggest that employees generally react negatively to attempts by external entities to influence their behavior.

Fifth, as predicted, momentary increases in negative affect predicted momentary

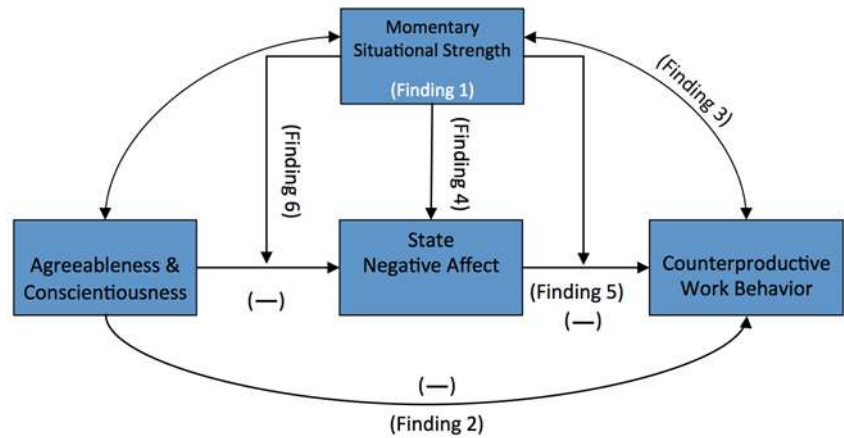


Figure 1. Model tested via the Experience Sampling Method in Project 4.

increases in counterproductive work behavior. This finding is important because it provides a key insight into one psychological mechanism that can help explain why increased situational strength leads to negative emotional experiences, which then leads to increased counterproductive work behavior.

Sixth, partially consistent with our expectations, the aforementioned process was more pronounced for employees with low levels of Agreeableness, though not for those with low levels of Conscientiousness. This partial support suggests that another (i.e., non-emotional) pathway may exist that explains this effect for Conscientiousness.

Data collection on two additional research projects has not yet begun. One of these projects pertains to the relative importance of situational strength emanating from various sources (e.g., supervisor, coworkers, upper management) in generating perceptions of overall situational strength and, ultimately, in affecting performance. The other project pertains to an investigation of unconscious (as opposed to conscious) situational strength generated by non-verbal and emotionally laden stimuli.

Contributions to Basic Research

Psychologists have long argued that it is important to understand the effects of “the person” and “the situation” on human emotions and behavior. Research on the person-side has yielded numerous systems to quantify key variables (e.g., personality, intelligence, interests), but research on the situation-side lags behind, in that no universally accepted system exists for classifying situations and/or the dimensions that define them. We argue that one key distinction lies in differentiating between the “content” of situations (i.e., the specific behavioral messages sent by situations) and the “strength” of situations (i.e., the forcefulness of these messages). One analogy sometimes used to capture this distinction involves the comparison of situational content and situational strength to the dials on a radio. Specifically, the channel dial on a radio determines what will be heard, whereas the volume dial determines how loudly that message will be projected. Situational content is analogous to the radio’s channel dial, whereas situational strength is analogous to its volume dial. Critically, the present study shows that, regardless of situational content, strong situations have important effects on employees’ emotional and behavioral experiences.



Further, these effects are more pronounced for employees with an already deleterious trait profile.

In the coming months, we will continue to use this dataset and general framework to test related ideas pertaining to additional personality traits, motivational/emotional states, and specific facets of situational strength. It is our hope that this line of research will continue to shed important light on the ways in which various types of individuals respond to various types of situations. Thus, these findings will also have important implications in the context of the other projects funded as part of the present research contract. For example, we predict in Project 3 that (a) situational strength can also exist beyond conscious awareness, but that (b) it will not lead to negative emotional states and, hence, negative behavioral outcomes such as counter-productive work behavior. That is, we hope to show that the negative effects of situational strength come not from having one's behavior influenced by external entities, but from being aware that one's behavior has been influenced.

In addition, research on situational strength can and should be used to inform research on the other side of the coin: personality strength. The definition, measurement, and likely effects of personality strength should be influenced by situational strength research. Indeed, we are already taking our own advice and beginning research on personality strength. We discuss this project in more detail in the Future Plans section.

Potential Army/Military Applications

The most direct implication of the present project for the U.S. Army involves better predicting the conditions under which certain types of Soldiers are at an increased risk of engaging in deviance/malefeasance. Typically, the primary driver of emotions

in military environments is thought to be their inherent danger, but the present research also suggests that the presence of behavior-relevant information might also be a source of negative affect and might contribute to deviant behaviors for certain types of Soldiers. Thus, 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 constantly changing environments. 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 and complex environments that often involve non-state actors who adopt unconventional methods. As such, it is critical to understand how and why different types of Soldiers are likely to respond to changing environments in predictably unique ways, both for their own emotional well-being as well as the functionality and stability of their combat units.

These new challenges are motivating an Army-wide (i.e., systems-level) emphasis on Soldier adaptability, flexibility, and uncertainty management. Stated differently, some 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. On the other hand, however, other situations that Soldiers are likely to encounter may be much "stronger" than those experienced traditionally (e.g., due to changes in rules of engagement and/or increased consequences). As such, the Army would benefit from knowing how Soldiers are likely to react across environments defined by varying levels of situational strength. This includes, for example, research examining how leaders facilitate "sense-making" and create shared understanding among Soldiers through downward feedback.

An important large-scale applied research project would involve the estimation of situational strength for a variety of individual Military Occupational Specialties and/or common types of discrete situations Soldiers are likely to experience throughout the course of their Army tenure. These estimates could then be incorporated into an online database similar to O*NET (the Occupational Information Network; <http://online.onetcenter.org>) or even a database of discrete situations that could be remotely accessed by unit Commanders in the field. The incorporation of situational strength into such databases 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 momentary deleterious outcomes based on situational strength-based misfit. These databases would then be updated at systematic intervals in order to track changes in situational strength as the Army continues to adapt in response to changes in its mission.

Future Plans

We presented findings from Project 2 to the 2015 meeting of the Society for Industrial and Organizational Psychology. We submitted these findings to a peer-reviewed journal in late 2016. We completed data collection for Project 3 and are currently analyzing the data. We have submitted our write-up of Project 4 to the *Journal of Applied Psychology*.

Lastly, although we did not use time funded by the ARI contract to work on this endeavor, we recently wrote a review article on "personality strength" (the notion that certain types of individuals are likely to be less influenced by situational cues than others), which may be considered "the other side of the coin" from situational strength. This article was published in the *Journal of Management* in 2015. We are currently analyzing the data from an experience sampling study



we have conducted to test several of the propositions articulated in this review paper. We have also developed an idea for a dynamic test of the resilience process based on the personality strength concept—and we hope to turn our attention to this project in 2017.

Associated Publications

Dalal, R. S., Meyer, R. D., Bradshaw, P., Green, J., Kelly, E., & Zhu, M. (2015). Personality strength and the reduction of situational influences on behavior. *Journal of Management*, 41, 261-287.†

Green, J. P., & Dalal, R. S. (in press). How journals can facilitate the study of underlying situational characteristics distinguishing worker and professional samples. In press at *Industrial and Organizational Psychology*.†

Kelly, E. D., & Meyer, R. D. (under review). The Effects of Momentary Situational Strength, State Affect, and Trait Aggression on CWB & OCB: A Within-Person, Process-Based Test. Under review at *Journal of Applied Psychology*.

†This paper was not funded by the current contract, but was informed by our work on the current contract.



Predicting Success With Elementary Cognitive Tasks

Contract #: W5J9CQ-12-C-0037

Contract Dates: 27 SEP 2012 – 15 JUN 2015

PI: Meredith C. Frey

Institution: Otterbein University

Co-PIs/Subcontractors: Cynthia Laurie-Rose, Otterbein University

Measures currently used by the U.S. military, 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 in an effort to provide culture-fair testing across broad strata of the population. The current research seeks to develop a computer battery that more directly measures the basic processes of intelligence utilizing elementary cognitive tasks, providing the Army with selection tasks that are less biased.

ARI has expressed 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, and theorists postulate that working memory (WM) is strongly related to both attention and intelligence. In addition to the timed measures, the subjective experience of subjects—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.

Our plan is to collect data from 600 participants over a 2-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 measures. While we seek to avoid measuring learned information, we intend to employ tasks that are quite difficult (see Figure 1 for an example task). 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 gender and racial/ethnic groups, and workload data will be used to investigate resource allocation in very demanding tasks.

Accomplishments

Since our last report, we have disseminated our findings in the following ways: (a) Year 1 and initial Year 2 results were presented at an IPR briefing in November 2013, (b) complete Year 1 results were presented at an international conference in December 2013, and (c) a manuscript exploring one aspect of the cognitive task battery—an abbreviated attention task—was sub-mitted for publication at



the *American Journal of Psychology*. While there is great interest in abbreviated attention tasks that can be employed in conjunction with other tasks, Year 1 data indicated that this task was not ideal in assessing vigilance. In short, participants were not required to pay attention long enough to make that part of the task challenging. Subsequent modifications have resulted in an attention task that preserves the characteristics of the original task but includes longer periods of time where people must remain alert and focused on detecting targets that appear onscreen.

This modified task appears in the Year 2 battery tested on 232 participants, and results indicate that the changes to the attention portion have yielded more classic decrements in performance. In total, performance on the task battery predicted 16 – 31% of the variance in academic achievement. We received a favorable review of the manuscript and are in the process of completing some minor revisions to the paper; we anticipate an acceptance in the coming months.

Contributions to Basic Research

The first manuscript that stems from this contract primarily concerns an abbreviated attention task that we modified across the periods of data collection. The attention task was originally modeled closely after one proposed by Helton and Russell in 2011. This framework, however, proved to be a poor indicator of a person's ability to sustain attention in our sample. In short, participants were not exhibiting classic declines in performance that we would expect from a task that requires them to attend to specific events and ignore others over a period of time. Due to these surprising results, we were motivated to modify the original task to include longer periods of sustained attention. This modification has produced the appropriate declines in

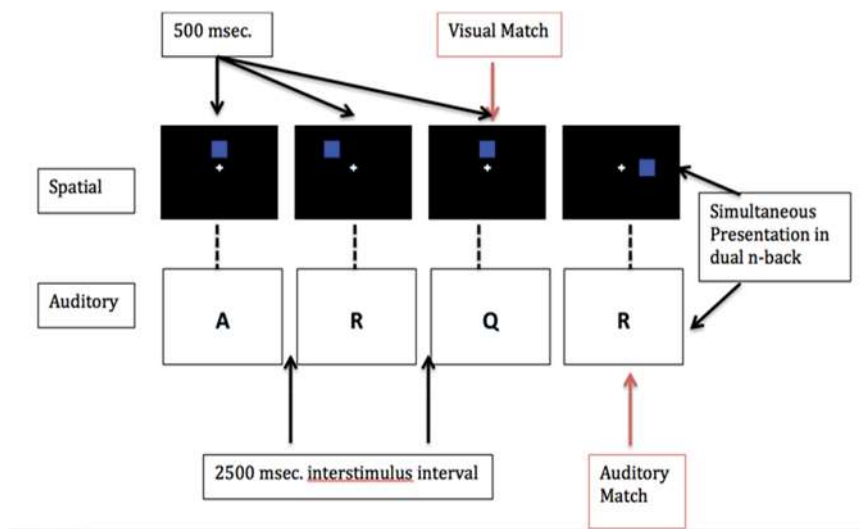


Figure 1. A dual 2-back complex working memory task. The task requires that participants simultaneously process and remember the location of blue boxes that appear onscreen and letter sounds that are presented over headphones. Every time the location or the sound matches one presented two items ago,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

performance, and it has given us an unexpected contribution to basic research as a result of this contract. Many attention researchers are interested in developing abbreviated tasks for inclusion in longer batteries of tasks, and a great deal of the literature is devoted to finding appropriate vigil lengths. Our findings on the attention tasks across Years 1 and 2 will be included in this literature.

More broadly, the goal of this research is to establish a computer-administered battery of cognitive tasks that can be used to predict success in a broad sample. We believe we have made important gains in this goal as well. Specifically, preliminary analysis of our Year 2 data indicates that the nonverbal computer-administered task battery is essentially equivalent to more traditional assessments (the ACT test) in terms of predicting our success criteria (see Figure 2). We chose ACT scores as our traditional assessment for four reasons: (a) it was the most widely used college admission test for Ohio colleges and universities, (b) it was available for nearly all participants, (c) it has been shown to correlate strongly with a general factor extracted from the ASVAB

subtests, and (d) it has been shown to be a very strong predictor of college GPA.

In order to place these results in proper context, it is important to note differences that exist between our battery and the traditional assessments currently employed. First, unlike the ACT test, the battery we designed can be completed with minimal reliance on previously learned information and may be more resistant to certain environmental factors, such as school quality. Second, and perhaps equally important, the battery we designed can be completed in under 90 minutes, including instructions, opportunities for self-paced breaks, and debriefing. We contrast this with the ACT, which takes nearly 3 hours of direct testing time, exclusive of breaks. Including breaks and instructions, the actual administration time of the ACT is just over 4 hours. Finally, we note that much of the extant research into the predictive utility of specific cognitive abilities has focused on academic achievement in school-aged children; therefore, this research in an adult population represents an important augmentation of the literature.



Potential Army/Military Applications

According to Broad Agency Announcement W5J9CQ-12-R-0002, the U.S. Army seeks the following under Basic Research: Identifying, Assessing, and Assigning Quality Personnel. This research domain is concerned with identifying and measuring the aptitudes and skills that are unique to the human performance requirements of the Future Force and the sociological and psychological factors that could influence recruitment, retention, and Army Performance.

While the ASVAB is a good measure of general cognitive 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 representative 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 U.S. Army be able to quickly identify those individuals who possess the cognitive skills 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 program developers to directly measure the cognitive processes responsible for the differences and, ideally, develop training methods to remedy such differences.

An additional area of strength for the battery tested is its potential to be administered in a large-scale format to recruits in approximately 90 minutes. Because the tests employed in this battery can be rigorously controlled and manipulated, there is the further possibility of developing a computer-adaptive version of the battery that can accurately gauge a recruit's ability with relatively few items. While this application may be a few years in the future, the fundamentals of the battery employed lend themselves nicely to this type of modification.

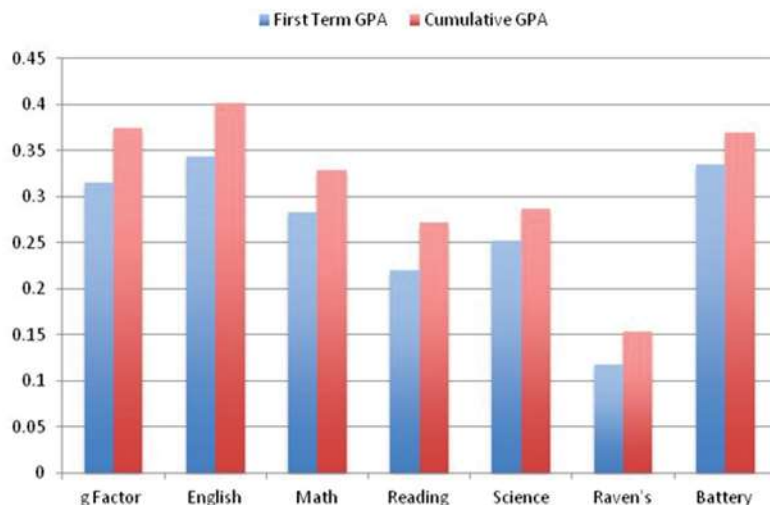


Figure 2. Correlations with success criteria. Preliminary results from the Year 2 battery indicate that a 90-minute computer-administered test of basic cognitive abilities can predict academic success essentially equally as well as can more traditional and more time consuming measures. In this figure, the g factor is extracted from the four ACT subtests (English, Math, Reading, and Science) with the addition of a short form of the Raven's Advanced Progressive Matrices, a 12-item nonverbal test of fluid reasoning ability.

Final Summary

This research domain is concerned with identifying and measuring the aptitudes and skills that are unique to the human performance requirements of Army personnel and the psychological factors that could influence recruitment, retention, and Army performance. Many attempts to assess aptitude (including the ASVAB) are laden with items that include reference to learned information and acculturated knowledge. A nonverbal battery of cognitive tasks that can demonstrate high predictive validity in a general population may very well prove useful in the selection and assignment of Army personnel. To date, we have presented results from this research at two international conferences and one regional conference. In addition, a paper based on Year 1 data has been accepted for publication in the *American Journal of Psychology*. A



manuscript from Year 2 data is in preparation, and we plan to submit this paper to the journal *Intelligence*.

Associated Publications

Frey, M. C., & Laurie-Rose, C. (2013, December). *Perceived workload and performance in difficult nonverbal cognitive tasks predict academic achievement*. Paper presented at the meeting of the International Society for Intelligence Research, Melbourne, VIC, Australia.

Laurie-Rose, C., Frey, M. C., Sibata, E., & Zamary, A. (under revision). The effects of working memory load and order on short duration sustained attention tasks. *American Journal of Psychology*.



Integrating Trait, Subjective Judgment, and Physiological Measures: Cognitive, Perceptual Speed, Psychomotor Performance, and Sustained Operations

Contract #: W911NF-13-1-0441
PI: Phillip L. Ackerman

Contract Dates: 01 OCT 2013 – 30 NOV 2017
Institution: Georgia Institute of Technology

This research is designed to study individual performance, effort, and attention through the combined use of psychological traits (including traits associated with ability, personality, and motivation) and key physiological indicators of arousal, stress, emotional reactions, and activity. The relationship between traditional individual differences and physiological measures will be explored and used to help develop new ways of using sensor data to model and predict individual engagement.

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.

Recent developments in hardware and software in the military, health care, and research domains have reached a point where such real-time assessments of key physiological variables (e.g., heart rate, skin temperature, galvanic skin response, respiration rate, and activity) can now be made for multiple individuals simultane-

ously. In the current research program, these key physiological assessments will be taken during baseline (in and outside of the laboratory), during task performance, and anticipation/recovery periods to determine the associations between individual differences in physiological reactivity and modulations in effort, subjective perceptions, and performance.

The goal of this research program is to integrate individual characteristics of ability, personality, and motivation (traits), and task characteristics across behavioral, self-report, and key physiological indicators of arousal, stress, emotional reactions, and activity. The approach taken is a multidisciplinary integration of several theory-based perspectives, including cognitive (ability), affective (personality), and conative (motivation or will). This integrated framework is extended to two broad physiological processes—a behavioral activation system (that is associated with approach or task engagement) and a behavioral inhibition system (that is associated with avoidance or a desire for disengagement). Together, these processes are to be examined in the context of performance and physiological reactivity during cognitive, perceptual speed, and psychomotor testing, during

sustained operations, and under different motivational interventions.

Research Approach

Based on the use of portable physiological recording devices (heart rate, respiration rate, and galvanic skin response), and a previously validated set of assessment measures (cognitive, perceptual speed, and psychomotor abilities), skill acquisition, and sustained performance measures, the goal is to triangulate the ebb and flow of individual effort levels, performance, and subjective experiences of effort, perceived fatigue, and stress. Additional investigations will focus on whether physiological markers anticipate or follow performance and subjective estimates of effort during stress, engagement, and fatigue conditions. From these data, individuals will be classified in terms of over-responders (people who have large fluctuations of physiological markers for effort allocations), normals, and under-responders (people who evidence minimal physiological reactivity to task demands).

Accomplishments

There were three major challenges to be met in this project. The first challenge was to complete acquisition of the ambulatory physiological assessment devices and acquire skill in using the hardware and software for post-processing the data. The second challenge was to implement physiological data collection in the context of assessments of cognitive, perceptual speed, and psychomotor abilities, along with subjective judgments in large-scale individual differences experiments. The third challenge was to select key physiological measures from an array of assessments and determine whether patterns of participant physiological reactivity could be used to triangulate with performance measures and subjective estimates of effort, fatigue, etc.



To meet the first challenge, we invested considerable time and effort in the first quarter in selecting the most promising hardware and software technology for ambulatory physiological assessments, namely the Equivital systems (including recording module, heart-rate and respiration measurement chest straps, and galvanic skin response [GSR] modules and finger sensors) and the Vivosense software for post-processing data from the Equivital systems. As with adoption of any cutting-edge technology, there was a series of obstacles that had to be overcome, including limitations of the recording devices that were not immediately apparent at the pre-purchase evaluation stage (e.g., belt fitting difficulties, situations where recordings were intermittent or degraded, determining optimal time-slices for assessment purposes, handling recording anomalies in post-processing). Some of these issues were addressed in the initial pilot-testing of the systems, and some (e.g., the data post-processing issues) are ongoing issues that we are still working through.

Meeting the second challenge required tailoring our previous protocols for assessment of individual differences in cognitive, affective, and conative (motivation/effort) variables to accommodate the additional requirements for belt-and-module fitting, establishing physiological baseline measurement periods, and providing for time-synching physiological and psychological/behavioral assessments. During the second quarter, we worked through these issues sufficiently to allow for completion of the first empirical [baseline] study, with minimal loss of physiological data. During the third quarter, we extended these procedures with pilot testing and the start of data collection on the second empirical study [examination of physiological reactivity under different task speed/accuracy trade-off instructions].

Meeting the third challenge—to select key physiological measures from an array of assessments—is an ongoing task. The re-

ording devices and post-processing software provide a large array of candidate physiological variables (ranging from baseline heart rate, GSR, and respiration rates, to a variety of heart-rate variability measures). To date, we have identified a set of fewer than a dozen variables, and are currently evaluating the psychometric properties of these variables (e.g., reliability and communality). The process of settling on a final set of variables is an iterative process, which will involve triangulation with performance and subjective estimates of fatigue, effort, and task-oriented affect. Figures 1 and 2 provide examples of the kinds of data we have processed so far. The first figure shows the high-frequency component of heart rate variability samples for three participants across a single session of Study 1. The second figure shows the GSR (raw measurements) for another three participants in Study 1. These figures illustrate the differential patterns of reactivity to different portions of the study protocol (e.g., during cognitive ability testing and perceptual speed testing). We expect to have additional progress made in meeting this challenge by the end of the fourth quarter.

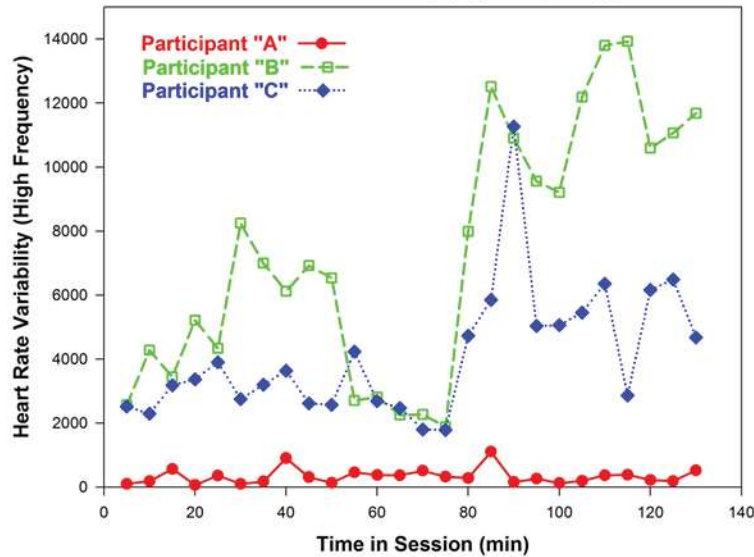


Figure 1. Sample heart rate variability (high frequency) data from Study 1.

Contributions to Basic Research

The main activities of the project to date have been in evaluating the ambulatory physiological recording devices, acquiring expertise in integrating physiological variable recording into large-scale assessments of individuals during testing and task performance, and data processing. As completion of the data analyses for Study 1 is accomplished, along with completion of data collection/analyses from Study 2 and Study 3, it is expected that there will be a sufficient basis for contributions to basic research in terms of both methodological techniques and substantive content (integrating physiological measures with performance measures and subjective judgments of effort, fatigue, and so on). These initial contributions from the first three studies are expected to be completed in the next several months.

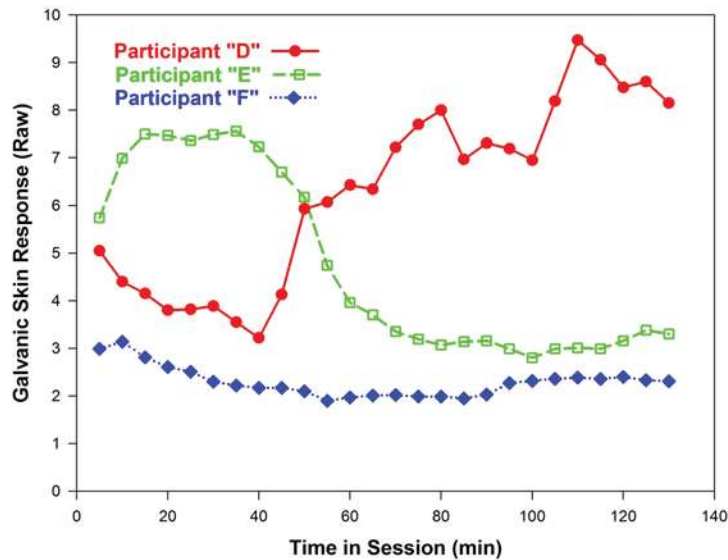


Figure 2. Sample galvanic skin response (raw) data from Study 1.

Potential Army/Military Applications

Modern psychology has amassed considerable theory and empirical research on four major domains: (a) individual differences in cognitive, affective, and conative traits; (b) categorization of task demands, in terms of both cognitive information processing and to a lesser degree, affective and self-regulatory demands; (c) physiological responses to a variety of psychologically-derived stimuli and situations; and (d) research on the nature and course of mental/cognitive fatigue. Together, these domains have yielded significant contributions to the prediction of both group-level performance measures and the prediction of individual differences in performance. Group-level predictions of performance have been greatly enhanced over the last century on the basis of a variety of different task analysis approaches, with early salient developments from efforts by Taylor and Gilbreth from time and motion studies, and strides into

critical incident techniques (Flanagan) and engineering psychology (Fitts) that were developed by the U.S. Army Air Forces during WWII.

Nonetheless, there has been a paucity of research efforts that have made significant progress toward integrating these various domains so as to provide predictions of real-world performance of individuals, beyond assessment of abilities and major personality traits. For example, predicting which individuals will respond to conditions of mental fatigue by increasing effort, decreasing effort, or keeping a steady level of effort, is something that has not yet been achieved, despite considerable research efforts. Prediction of individual differences in vigilance-type task performance is not much better, even though this is a job/task that has central importance to both military and civilian applications.

There are several short-term and long-term potential applications of the current research program. In the short term, the categorizations of individuals in terms of their physiological reactivity may be

applicable to measurement and prediction of engagement-involvement of individuals in a variety of different job/tasks, which in turn, may be used in the context of training interventions. Because the methodology of physiological assessment being developed and implemented in these studies allows for real-time assessments of physiological reactivity, it may be possible to assess both individual cognitive loads and individual engagement-involvement in tasks. Such information may be useful in determining the level of challenge or difficulty that is most suitable in training designs, to maximize learning and skill acquisition, and to determine when individuals are being asked to process novel information or tasks that are beyond their “zone of tolerable problematicity.” Similarly, real-time assessments of perceptual speed, psychomotor performance, physiological reactivity, and engagement-involvement might be used to determine ‘suitability for sustained operations’ for individuals, based on the linked performance/physiological status data, especially for mission-critical tasks.

In the longer term, achieving an understanding that links individual differences in abilities, personality traits, and interests with individual differences in physiological reactivity to task demands across different task domains (e.g., cognitive, perceptual, psychomotor), may inform decisions about selection (in terms of predicting the individual’s suitability for training or specific jobs/tasks) or classification decisions (such as high-stress or low-stress tasks, team/individual tasks, cognitive/perceptual demand tasks, etc.).

Future Plans

Future plans are largely summarized in the original research proposal. For the remainder of Year 1, the main projects are data analysis of Study 1 (baseline), completion of Study 2 (speed/accuracy trade-off), and Study 3 (skill acquisition), with later studies to evaluate physiological markers for reactivity



during sustained operations and physiological indicators of effort, and fatigue, under motivational interventions. In addition, based on suggestions from ARI researchers, I hope to augment the current physiological assessment procedures with new devices that are coming on-line to assess outside-the-lab physiological activity, heart rate patterns, and rest cycles (to be supplemented with assessments of caffeine intake, fluctuations of mood and positive/negative affect).

As data collection and data analyses are completed, I expect that the scientific efforts (e.g., presentations and publications) will have a two-pronged focus, namely: First, to spell out the methodology of integrating physiological, behavioral, and subjective judgments of effort, engagement and fatigue; and second, to focus on the accuracy of categorizing individuals in terms of engagement-involvement and aversion-disengagement testing conditions, during skill acquisition, and under fatigue-inducing performance conditions, and on the relations between trait indicators and physiological response profiles.

The overarching goal of this project is to integrate physiological assessments with trait measures (ability, personality, motivation), performance measures, and subjective judgments of effort, fatigue, and affect—before, during, and after expenditures of cognitive effort during ability assessment, learning/skill acquisition, and in reaction to interventions designed to increase task-oriented motivation. From the current and planned studies, the aim is to provide: (a) methodological tools/procedures for integrating physiological measures with behavioral data and subjective judgments; (b) an empirical basis for categorizing groups of individuals in terms of physiological reactivity and alignment of physiological responses, individual differences in performance, and individual differences in subjective evaluations of effort expended in task performance; and (c) an explicit theoretical account of (a) and (b) above.



An Evaluation of Alternative g Tests

Contract #: W911NF-13-1-0353
PI: Michael A. McDaniel

Contract Dates: 27 SEP 2013 – 26 June 2017
Institution: Work Skills First, Inc.

The goal of this research is to explore some of the psychometric and theoretical issues surrounding the development and use of cognitive ability tests. Specifically, this research seeks to test the extent to which the dominance of a general factor of intelligence (“g”) is associated with group differences in some of the psychometric characteristics, structure, and validity of these tests. In addition, tests based on different theoretical approaches to defining cognitive ability will be compared, and the characteristics of specific items will be explored.

Some have sought to develop tests of general cognitive ability (g) that are good tests of g but which have low mean racial score differences. We refer to such tests as “alternative g tests” to distinguish them from g tests common to the psychometric g literature (such as the ASVAB). In this research, we seek to evaluate the credibility of Spearman’s Hypothesis as an explanation for results common to alternative g tests.

Spearman (1927) addressed this question: What causes one g test to have smaller mean racial differences than another? In response, he noted that the magnitude of mean White-Black differences co-varied with the extent to which a test was “saturated with g” (Spearman, 1927, p. 379). By “saturated with g,” he meant the extent to which the test measures g. The positive relationship between the g saturation of tests and the magnitude of the tests’ White-Black mean differences became known as “Spearman’s Hypothesis.” To accept Spearman’s Hypothesis is to argue that one cannot develop a g test that measures g well (i.e., a test that has high g saturation), but with low White-Black mean differences. Given that this is a dire conclusion, some researchers have sought to develop measures of g that have high g saturation but that also have low mean racial score differences.

Thus, these alternative g researchers seek to find exceptions to Spearman’s Hypothesis.

In the project, we examine Spearman’s Hypothesis as an explanation for results common to alternative g tests. We do this in four steps. First, we obtained two alternative g tests. Also, we developed conceptually similar item sets to the test we were unable to obtain from an alternative g test vendor. Second, after ARI human subject approval, these alternative g tests are to be administered along with traditional assessments of g. Third, the g saturation of all administered tests would be determined, and a comparison of g saturation with mean racial differences would be made. Fourth, we would evaluate validity and prediction errors as a function of g saturation.

If the results are consistent with Spearman’s Hypothesis, this would permit the claims of alternative g researchers to be refuted, and employers would have evidence to demonstrate that such measures are less effective than traditional g measures. On the other hand, if the g saturation of the alternative g scales is not fully consistent with Spearman’s Hypothesis, then the alternative g scales are worthy of additional attention.

Research Approach

During the first year of the project, two alternative g tests were obtained and others were developed. Traditional (psychometric) g tests were drawn from public sources; others were developed. After ARI human subjects approval is obtained, the final test battery will be administered through the Internet to adults 18 years and older who reside in the United States. Analyses will be conducted to evaluate g saturation, mean group differences, validity, and prediction errors. Results consistent with Spearman’s Hypothesis would resemble Figure 1, which indicates that both validity and the mean group differences increase as g saturation increases.

Potential Army/Military Applications

As noted on the Army Diversity website (<http://www.armydiversity.army.mil/index.html>), “Every U.S. Army Soldier ... has a different background, culture, and thought process from which he or she can draw. When these separate differences are combined and work together, it contributes to an adaptive, culturally astute Army that further enhances our capabilities around the world.” Thus, the Army not only seeks to bring the best talent into its organization, but to tap the diverse characteristics, experiences, and backgrounds of its members to enhance the mission of the Army.

A key component of the Army’s diversity mission is the talent management process, which includes screening of aspiring recruits to ensure both excellent performance in the Army and racial diversity. To assist in the Army’s mission to obtain the best talent, aspiring recruits are screened with the ASVAB. The ASVAB is primarily an assessment of cognitive skills. There is substantial evidence that the ASVAB does an excellent job of identifying those with the cognitive skills



needed for successful performance in the Army. However, the use of the ASVAB yields the same dilemma found with all tests assessing cognitive skills. Specifically, there are typically mean racial differences in ASVAB test scores favoring Whites and Asians and disfavoring Blacks and Hispanics. This circumstance is often termed the validity–diversity dilemma because using a cognitive test to select the best talent often results in a racially unbalanced workforce. Thus, it is in the best interests of the Army to consider ways of resolving the validity–diversity dilemma.

Given the validity-diversity dilemma, some researchers seek to develop alternative g tests in an attempt to measure cognitive skills well but with lower mean racial differences. If it is true that alternative g tests measure cognitive skills well and predict job performance (i.e., have validity) as well as traditional g tests such as the ASVAB, one needs to also evaluate whether such tests have lower mean racial differences. If the mean racial differences of the alternative g tests are smaller than the traditional g tests, the Army may have the opportunity to resolve the validity-diversity dilemma.

The challenge is to determine if the claims made regarding alternative g tests are true. Thus, this research seeks to evaluate the claims made about alternative g tests to determine their value for the Army. We seek to know if the alternative g tests assess cognitive skills as well as traditional g tests. We also seek to know whether they are as valid as traditional g tests in predicting job performance and result in reduced mean test score differences among races.

Future Plans

In the first year of the contract, we obtained alternative g tests and traditional g tests. We also developed alternative g tests with item types conceptually similar to an alternative g test that we were unable to obtain from its owner.

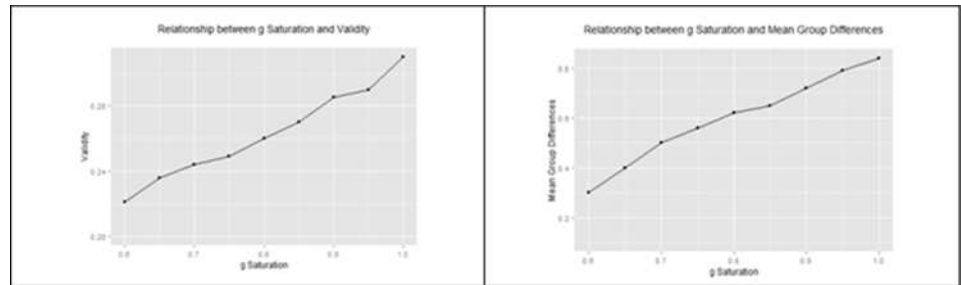


Figure 1. Illustrative results consistent with Spearman's Hypothesis.

We await ARI human subjects approval needed to pilot test these measures. After receipt of ARI human subjects approval and pilot testing, the resulting items will be assembled into the final test battery. After the final test battery has received human subject approval, it will be administered through the Internet.

Respondents will be screened to restrict the sample to those who are at least 18 and who have sufficient literacy to comprehend the test battery. We anticipate collecting data from approximately 400 Whites, 400 Blacks, 400 Asians, and 400 Hispanics. This should provide adequate data for the analyses needed for this research.



Individual Differences and Adaptive Flexibility: A Psychoneurometric Analysis

Contract #: W911NF-14-1-0018

Contract Dates: 1 APR 2014 – 31 JUL 2019

PI: Christopher J. Patrick

Institution: Florida State University

Co-PI: Walter R. Boot, Florida State University

This research uses a multi-faceted conceptual and methodological approach to investigate the influence of key individual difference variables on adaptive flexibility. These include studying the effects of boldness-fear and inhibition-disinhibition. The research also makes use of a new approach to psychometric-neurophysiological assessment, using a joint approach to measuring and conceptualizing these individual difference constructs.

The ability to adapt to situations involving dynamic change and stress or uncertainty is crucial to effectiveness at all levels of military service. This research project is directed at developing and validating new methods for assessing dispositional characteristics that contribute to adaptive flexibility in challenging performance contexts.

This project involves a novel approach to assessment, combining bio-behavioral dispositions that can be quantified reliably through use of physiological (e.g., brain) and behavioral (e.g., response speed/accuracy) measures along with traditional self-report measures.

We hypothesize that dispositional characteristics assessed in this way will predict on-line performance in dynamic tasks more accurately than dispositions assessed through self-report alone—and by extension, prove more effective for assigning personnel to service duties that call for adaptive flexibility.

This research focuses on two dispositional characteristics relevant to military applications: boldness (fear/fearlessness) and self-control (inhibition/disinhibition). Substantial evidence points to a biological basis to these dispositions, and reliable physiological correlates have been demonstrated for each. For

example, high boldness is associated with reduced fear in contexts of threat as indexed by noise-probe startle response, and high disinhibition is associated with reduced recognition of mistakes in task contexts as indexed by error-related brain response.

Research has also shown these dispositions to be important for behavioral performance. High-bold individuals are less distracted by incidental threat cues when performing an instructed task, and high-disinhibited individuals exhibit impaired performance on tasks that call for suppression of prepotent responses.

The current project uses a well-established lab performance procedure, the task-switching paradigm, to evaluate effects of boldness and disinhibition on flexible responding under stressful and nonstressful circumstances. Major hypotheses are that: (a) high-bold individuals will show less disruption of flexible responding under conditions of physical threat, (b) disinhibition will exert a general deleterious effect on flexible responding, such that low-bold individuals highest in disinhibition will show the greatest decrement in task-switching performance under conditions of threat, and (c) physiological and lab-behavioral indicators of boldness and disinhibition will contribute to prediction of flexible

responding over and above self-report measures of these dispositions. This project will demonstrate the utility of the task-switching paradigm as a method for evaluating effects of biologically-based dispositions on an important facet of adaptability; flexible shifting of behavior. Follow-up research can provide for assessment of adaptive capabilities under conditions closer to real life by incorporating the task-switching procedure into more complex simulation tasks or live-action role-playing scenarios.

Research Approach

The two key elements of the research approach are: (a) use of physiological and behavioral as well as self-report measures to quantify individual differences in boldness and disinhibition, and (b) use of novel variants of the well-established task-switching paradigm to evaluate effects of these dispositions on flexible responding under stressful and non-stressful conditions. In a common version of the task-switching procedure, participants alternate between two tasks entailing responses to ongoing number stimuli (i.e., high or low, odd or even) based on the font-color of numbers. In the current project, we are using an alternative ‘face-stimulus’ version (see Figure 1), with performance of task-switching under conditions of threat (i.e., a concurrent cue signaling the possibility of shock) or safety (i.e., no concurrent shock cue). Prior to the task-switching procedure, participants (university undergraduates and adults from the general community) complete questionnaire measures of boldness and disinhibition and undergo affective and cognitive task assessments designed to yield physiological and behavioral indicators of these dispositions.

Accomplishments

A major aim of the project is to establish feasible new methods for assessing individual differences

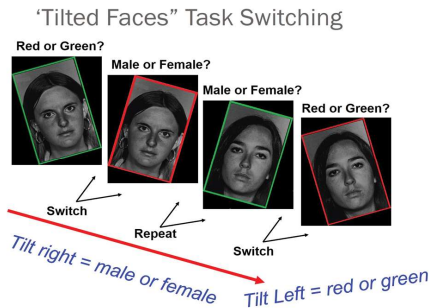


Figure 1. Schematic of ‘faces’ task-switching paradigm used in current project. For faces tilted toward right, task is to indicate (via left/right button press) whether the face is male or female; for faces tilted toward left, task is to indicate whether the frame surrounding the face is red or green in color.

in traits relevant to adaptive performance. During the past year, we advanced this aim in major ways.

First, we completed pilot testing and initial validation of our experimental tasks and measures. This involved creating and verifying the effectiveness of our novel “tilted faces” version of the switched-task paradigm. We have also verified the effectiveness of the shock-threat procedure for eliciting fear (see Figure 2) and conducted preliminary examinations into the relationship between boldness and performance under threat vs. non-threat conditions (Figure 3).

Data have been collected from approximately 90 participants. This includes both biobehavioral measures of fear (e.g., blink response), psychometric measures, and task performance data.

Finally, work on this grant has produced a number of publications and presentations relevant to the assessment of individual differences using both psychometric and biobehavioral measures. This includes a key paper on the joint psychometric-neurophysiological assessment of dispositional boldness/fear, to appear in a special issue of *Psycho-*

physiology; several papers on theoretical models of personality related to boldness and disinhibition; and a number of formal presentations of our findings and theoretical approach at scientific conferences.

Contributions to Basic Research

A major aim of the project is to establish feasible new methods for assessing individual differences in traits relevant to adaptive performance. During the past year, we advanced this aim in major ways, including: (a) completing a key paper on joint psychometric-neurophysiological assessment of dispositional boldness/fear to appear in an upcoming special issue of *Psychophysiology*, (b) collecting psychometric-scale, task-behavioral, and neurophysiological measures from ~ 90 participants as a step toward establishing a new multi-domain assessment of trait inhibition-disinhibition (I-D)—with plans to expand this to $N = 160$ during the coming year.

The tasks, measures, and analytical models developed for this research project have the potential to provide new ways to integrate psychometric measures and biobehavioral measures in a way that allows for a better understanding of individual differences related to inhibition/disinhibition and fear/boldness. This includes, for example, the refinement of methods using structural equation modeling (SEM) to combine measurements from across a wide variety of sources.

Potential Army/Military Applications

The current research will contribute to the Army’s mission by helping to optimize procedures for assigning personnel to tasks requiring distinct adaptive capabilities and skill sets. Findings from this work will contribute to the development of new assessment

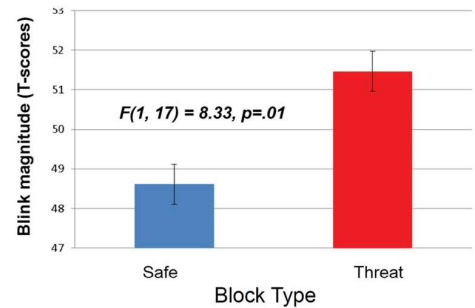


Figure 2. Pilot sample data ($N=18$) demonstrating effectiveness of the threat manipulation used in Study 1 of this project. In “threat” blocks, a cue indicates that a shock may be administered to the finger. In “safe” conditions, a cue indicates that no shock will be delivered.

tools for use in military classification and assignment, while also advancing scientific knowledge regarding the nature and neurobiological bases of dispositional characteristics that determine performance. Additionally, the work will have implications for training of military personnel.

The current experimental efforts help to lay the groundwork for future studies using more realistic performance simulations. To enhance realism while

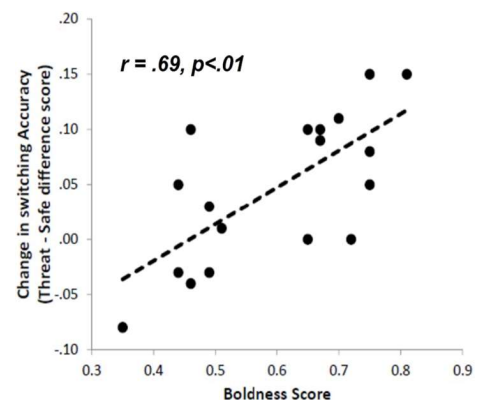


Figure 3. Relationship between differential performance accuracy during Threat vs. Safe task blocks as a function of Boldness scale score (pilot sample, $N = 18$). Whereas low-bold subjects show reduced accuracy in the shock-threat condition relative to the no-shock condition, high-bold subjects showed enhanced accuracy.



maintaining experimental control, the task-switching procedure (including threat/safe manipulation) can be adapted to simulations of social interactions or combat situations by altering procedural elements to achieve higher verisimilitude. For example, in place of colored numbers, cues signaling the need for shifts in responding could be presented during performance of vehicular operations in a driving simulator; a simulator of this type is available in project Co-I Walter Boot's Attention and Training Lab. Work of this kind would advance understanding of the impact of dispositional characteristics on real-world machine operation under circumstances akin to those commonly encountered in military settings (e.g., physical, psychological, or social stress, mental fatigue or boredom, attentional distraction).

The basic task-switching paradigm could also be modified to simulate features of military situations entailing deployment of troops or resources, or assignment of orders regarding movements or actions. Increased realism along these lines would provide new insights into dispositional characteristics relevant to performance and their neuro-physiological bases, as well as contributing to assessment methods and predictive success in real-world contexts.

In terms of long-term potential applications, the models and methods being developed in this project could help provide additional ways to make use of data from advanced biometric sensors or other sources and to integrate such data into a more complete picture of individual and group psychological states. Such measures could be used to help provide new methods of selecting or assigning military personnel—for example, by helping to identify how different individuals may be likely to perform under conditions of fear and stress.

Future Plans

The protocol for this study was finalized during Spring 2015 and full testing sessions were initiated during Summer 2015. Pre-selection occurs through classroom screening (undergraduates) and on-line questionnaire administration (community adults). Along with self-report measures, the testing protocol includes tasks that yield physiological and behavioral indicators of boldness and disinhibition, followed by performance of task-switching in alternating blocks of shock-threat (in which a cue signals the possible occurrence of shock) and non-threat trials. Testing sessions are being conducted by highly experienced lab personnel, with assistance from more-recently trained personnel. Each full testing session requires approximately 3.5 hours. Assuming replacement of 10-15% of test subjects, the overall number of participants for Study 1 is expected to be 92–97.

Our plan for the forthcoming year of the project is to complete the data collection for Study 1 and to pilot and implement procedures for Study 2, which entails a fairly straightforward variant of Study 1 (i.e., with shock-threat occurring on a trial-by-trial basis, rather than across blocks of task-switching trials). Questionnaire data are being entered and scored and digitized physiological and behavioral data are being processed for analysis as testing sessions for Study 1 proceed.

During the coming year, we will also continue devoting effort to preparation and submission of additional manuscripts and review articles/chapters related to the aims of this project.





LEARNING IN FORMAL AND INFORMAL ENVIRONMENTS

DR. GREGORY A. RUARK, RESEARCH PORTFOLIO LEAD

The operational environment of the Army over the last 10 years has created significant pressure on the Army training and educational institutions, 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 reach 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:
learning theory, learning methods, and 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, including individual and team training environments. Moreover, the program seeks to develop measurement techniques to assess metalearning (i.e., learning to learn) and to identify factors that impact metalearning in different learning environments.



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 23-32.

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.

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

(W5J9CQ-12-C-0048; 2012–2017)

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.

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

(W5J9CQ-12-C-0046; 2012–2016)

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.



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

Contract #: W5J9CQ-11-C-0047

Contract Dates: 27 SEP 2011 – 26 SEP 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 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 perceptual experts 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 Bel Air and the 1956 model. 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

In this contract, we aim to identify the visual characteristics and perceptual strategies that: (a) real world experts bring to bear to recognize objects from their domain of specialization, and (b) that can be emphasized during expertise training of novices. Here, we propose that: (a) color and surface information, (b) high spatial frequency information, and (c) motion information are critical features experts rely on for fast and accurate identification and recognition at the subordinate level. 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 within their domain of expertise. We hypothesize that relative to novices, experts will (a) better allocate their attention to relevant

stimulus features and dimensions, and (b) 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 that are 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 completed collecting data for Experiments 1, 2, and 5. Data collection for Experiments 3 and 6 will begin in Fall, 2014 and we will begin designing Experiment 4 in early 2015. The results of Experiment 1 were recently accepted for publication in the *Journal of Vision* and the results of Experiment 2 will be submitted to a peer-reviewed journal shortly. In Experiments 1 and 2, we employed psychophysical methods to test how bird experts use color (Experiment 1) and spatial frequency (Experiment 2) cues to facilitate their speeded recognition. Experiment 3 will directly probe the strategies of experts by monitoring their eye-gaze and manual exploration while encoding and recognizing objects of expertise. We will record visual fixations, scan paths, and manual tracking while novice and expert birders view and respond to images of

birds. Experiment 4 will use point-light displays to examine the importance of motion in expert bird identification. In Experiment 5, we trained novices with two different species of birds and tested the effects of training on their use of color and spatial frequency using both psychophysical and electrophysiological measures of brain activity. Data collection for Experiment 5 is completed and analyses are currently being conducted. For Experiment 6, we have completed stimulus creation and testing and will examine how two different training techniques influence attention to features (color, spatial frequency) and strategy use while we measure eye movements and electrophysiological measures of brain activity before and after.

Experiment 1: The Use of Color in Bird Experts and Novices (abstract modified from in press paper in *Journal of Vision*). We examined how color knowledge in a domain of expertise influences the accuracy and speed of object recognition. In Experiment 1a, expert bird-watchers and novice participants categorized common birds (e.g., robin, sparrow, cardinal)

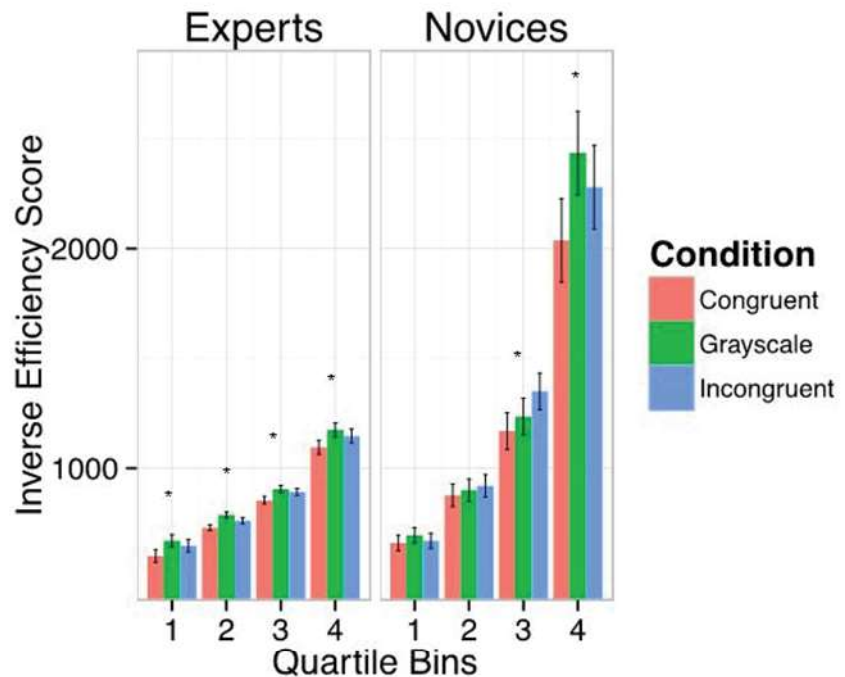


Figure 1. Experiment 1: Distribution of Inverse Efficiency Scores (IES) for the experts and novices. The IES is computed by dividing correct response time by proportion correct within each condition for each participant; a lower score means better performance. Bin 1 contains the 25% fastest responses of each participant. Bin 2 contains the next 25% fastest responses and so on. Error bars represent standard error.

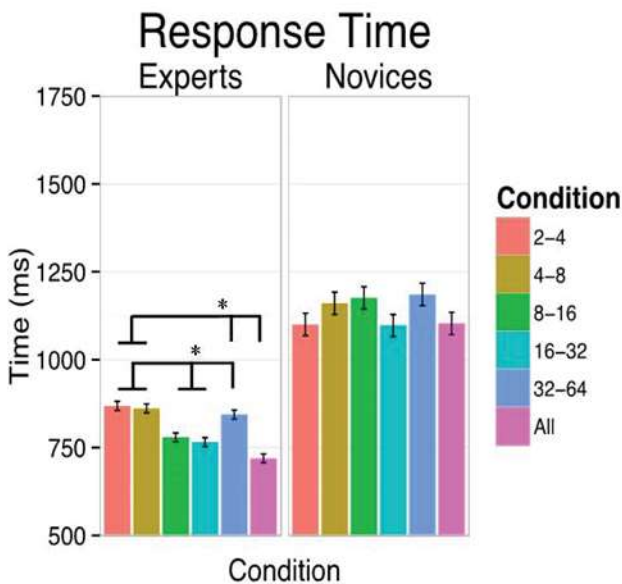


Figure 2. Response time for each group (expert, novice) as a function of Spatial Frequency condition (2-4 cpi, 4-8 cpi, 8-16 cpi, 16-32 cpi, 32-64 cpi, full spectrum). Error bars represent SE.

at the family level of abstraction. The bird images were shown in their natural congruent color, incongruent color, and monochrome.

Although both experts and novices relied on color to recognize birds at the family level, analysis of the response time distribution revealed that color facilitated expert performance in the fastest and slowest trials whereas color only helped the novices in the slower trials (Figure 1). In Experiment 1b, expert bird-watchers were asked to categorize congruent color, incongruent color, and gray scale images of birds at the more subordinate,

species level (e.g., Nashville warbler, Wilson's warbler). The performance of experts was better with congruent color images than with incongruent color and gray scale images. As in Experiment 1a, analysis of the response time distribution showed that the color effect was present in the fastest trials and was sustained through the slowest trials. Collectively, the findings show that experts have ready access to color knowledge that facilitates their fast and accurate identification at the family and species level of recognition.

Experiment 2: The Details of Expertise: The Importance of Spatial Frequency in Bird Experts and Novices. We investigated whether expertise relies on internal object features to facilitate fast and accurate subordinate-level recognition by filtering bird images over a range of spatial frequencies. This manipulation preserved the external shape of the object while systematically degrading its internal feature information. Results

demonstrate that an important source of the expert recognition is the internal information that is available at 8–16 cycles per image (cpi) bandwidth relative to 2–4 cpi, 16–32 cpi, and 32–64 cpi. This band of the spatial frequency information contributes to recognition independent of whether the external contour information is high (Experiment 2a) or low (Experiment 2b) in diagnosticity. Collectively, our results indicate that experts possess a broad repertoire of perceptual strategies that facilitate their speeded recognition of objects in their domain of expertise.

Experiments 5 and 6: Training Perceptual Expertise. The findings from Experiments 1 and 2 indicate that the experts have formed multicoded object representations that consist of shape, color, and internal details that contribute to their fast and accurate recognition abilities. Experiments 5 and 6 take what we have learned from bird experts and determine whether the important features identified in experts also contribute to the acquisition of expertise through training.

Experiment 5: Training Bird Expertise in the Laboratory. In this investigation, novice adults were trained to recognize several exemplars of different finch and warbler species. Before, during, and after this training, EEG and behavioral

responses were recorded. The training and pre- and post-test involves nine sessions per subject. Based on the results of Experiments 1 and 2, we aimed to determine whether or not we can train novices to discriminate these species and whether their post-training performance is influenced by color and spatial frequency manipulations. To date, we have completed preliminary analyses of behavior and found that similar to Experiment 1. Subordinate training increases benefits of color congruency and reduces non-specific color effects (Figure 3). However, unlike Experiment 2, where real-world experts use high-spatial frequency information early in recognition, laboratory-trained experts use low-spatial frequency information early in recognition and high-spatial frequency information later. These results suggest that for recently trained experts, low spatial frequency information provides fast, first-pass constraints on object recognition that are later refined by high spatial frequency information. Additional years of training by real world experts make even high spatial frequency information quickly available, which may obviate the need for the first-pass low spatial frequency constraints observed after recent training.

Experiment 6: Novel Object Training in Naïve Observers. We have developed a completely manipulatable artificial object stimulus set consisting of two families of 10 species and 12 exemplars within each species (240 stimuli). This stimulus set also includes color and spatial frequency manipulations (similar to Experiments 1, 2, and 5). To date we have conducted a pilot investigation to test whether or not naïve participants classify our stimuli into two families and different species. For this pilot study, novices rated stimuli as more or less similar on a 5-point scale. We used these ratings to create the average pair similarity rating for all of the species pairs. Figure 4 shows that novices appear to make a linear distinction between the two families. This similarity task will be included in the battery of pre- and post-training tasks and will allow us to determine whether our two different training protocols affect the distribution of similarity ratings. We also developed an extensive interest inventory (including questions about video game use, hunting experience, educational background, etc.) that participants will complete prior to training; we will use these data to determine whether training efficacy is related to specific items on this interest inventory.

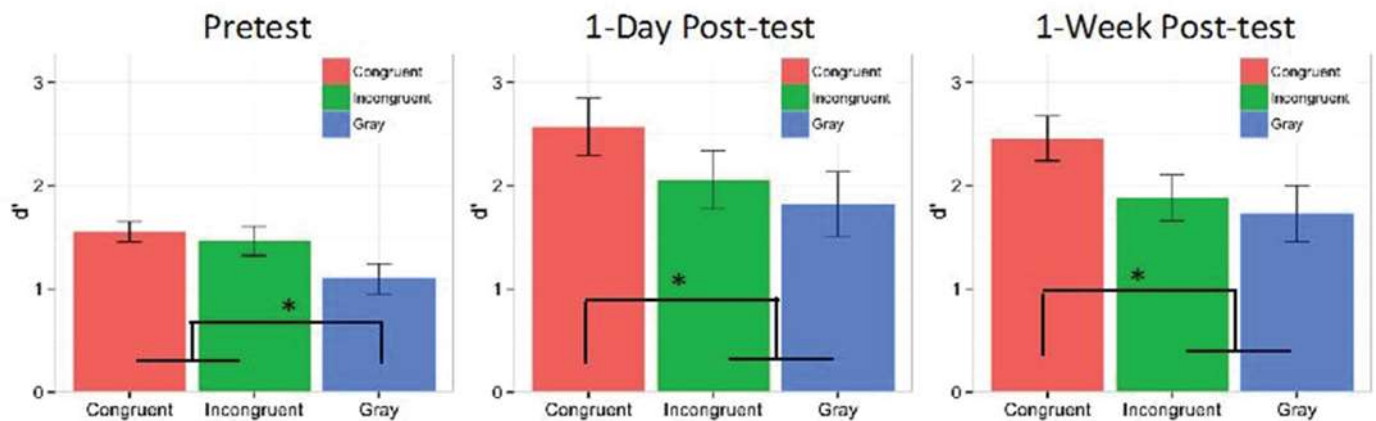


Figure 3. Accuracy (d') on a species matching task before (pretest), 1 day after, and 1 week after training. Before training, any color facilitated performance regardless of color congruency. After training, performance increased, especially for congruent colors.

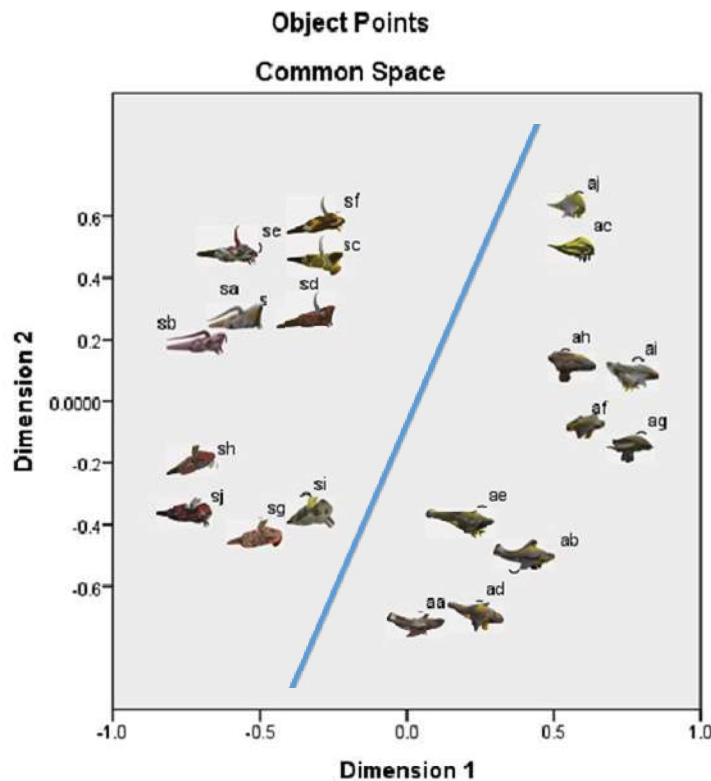


Figure 4. This shows the average pair similarity rating for all of the species pairs. To do this, 1 was added to the maximum rating (5) and each similarity score was subtracted from this total to create a dissimilarity score for each species pair. These scores were analyzed in SPSS using Multidimensional Scaling (PROXSCAL). The graph shows the species clumping into groups that are more similar and shows that novices clearly differentiate the two families (noted by the diagonal line).

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. To date, our findings suggest that color and fine details are critically

important for real world bird experts and for training perceptual expertise in the laboratory.

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, shape, and motion. 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 and novel object training 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 expertise within the domain of birds or within a novel object category should further our understanding of the acquisition of perceptual expertise in other object domains—many of which likely apply to the military, including threat detection and fast/accurate identification of faces or objects. In addition, our training experiments will help identify best practices for perceptual expertise training within the military. For instance, the findings from these experiments will elucidate how military personnel can be trained to utilize multiple perceptual cues (e.g., color, shape, motion) to become proficient at quickly and accurately recognizing threat-objects in the field. 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

We plan to complete data collection and analyses for Experiment 3 (“a window into the visual strategies of the expert”), as well as start to develop Experiment 4 (“dynamic motion cues and bird recognition”). We aim to complete data analyses and the write-up for our first training experiment (Experiment 5) and to complete data collection and preliminary analyses for Experiment 6. We are also in the process of testing real-world experts with a matching task that is used for laboratory training so that the results can be directly comparable for real-world bird experts and laboratory-trained bird experts.



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

Contract #: W5J9CQ-12-C-0048
PI: Scott Tannenbaum

Contract Dates: 29 AUG 2012 – 30 JUN 2017
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.

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). The premise of this research is that formal training can be enriched to serve as a catalyst for subsequent field-based learning.

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. 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). 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 is 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 has proceeded through two of three stages. In Year 1, the focus was on integration, conceptual development, and theory building. In Year 2, we have advanced the effort to correlational research examining key variables, including the development of a measure of field-based learning (FBL) and the identification of relevant measures of personal and situational antecedents of FBL. In Year 3, we plan to use our work from Years 1 and 2 to advance to quasi-experimental testing of FBL interventions.

Accomplishments

In Year 1, we established an initial model of Training to Accelerate FBL. This served as a launching point for our subsequent work, along with a preliminary set of research propositions. The model and propositions underwent revisions where needed. We conducted several tasks to synthesize and integrate the disparate literature related to FBL, seeking and collecting relevant studies to organize the integration process. Our Year 1 activities yielded two key deliverables: a quantitative meta-analysis of the literature on informal learning and extensive in-depth interviews with informal learning experts. Taken together, our Year 1 efforts were designed to provide a foundation to launch the Year 2 tasks.

Our Year 2 research plan first called for us to develop (and/or identify) a battery of relevant field-based learning

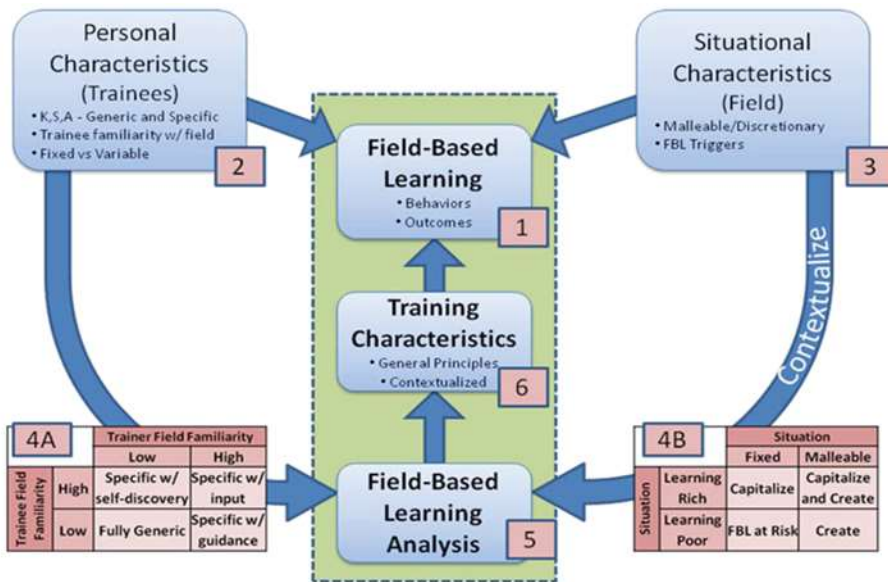


Figure 1. Training to accelerate field-based learning.

measures. A measure of FBL behaviors was developed based in part on input from subject-matter experts (SMEs), who provided insights regarding potential FBL behaviors as well as feedback on the content validity of potential items. The scale underwent iterations of psychometric evaluation and modification, ultimately yielding a 12-item measure. The new scale showed good psychometric qualities with evidence for three components of FBL: vicarious/observational experience, actions taken, and feedback received.

Our Year 2 efforts also called for conducting correlational research to begin to test some of our propositions. To do so, we needed to identify an organization with an ample number of employees who both demonstrate sufficient variability on personal factors of interest and who work in different enough settings to examine situational factors of interest. We located and vetted a sample from a healthcare setting (“hospital sample”) that met the criteria for our Year 2 research. While our theory suggests that there may be an interaction between personal and situational factors, our meta-analysis revealed that prior research had not examined that

possibility. Preliminary analyses from the hospital sample reveal some interesting interaction effects between variables of interest. We will be conducting further analyses on this data set, further exploring potential interactions as well as direct effects.

In summary, during Year 2 we built a measure of FBL behaviors and conducted preliminary correlational analyses on potential antecedents of FBL. In addition, we assembled a battery of measures that we intend to use during our Year 3 research efforts that will further explore the correlates of FBL and examine whether field-based learning can be accelerated.

Contributions to Basic Research

Existing research related to FBL has been 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, whether they are on-going activities, whether they are 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. We have provided a conceptual and quantitative synthesis of the literature that explicates the FBL construct and integrates multiple research streams. To date, there has not existed a useful theoretical foundation to guide research on how training can be used to stimulate FBL. By clarifying the construct, specifying the underlying theory, developing a battery of new measures, and articulating research hypotheses, our groundwork provides a significant advancement in our basic understanding of FBL. In addition, by providing a new framework for conceptualizing the broader organizational learning domain, we have enabled and fostered a stream of meaningful basic research to test and refine the theory.

Our model of FBL has been 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 is 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.

Evidence that personal and situational factors influence FBL have been provided by our quantitative meta-analysis and our in-depth SME interviews. For example, the meta-analysis confirmed the importance of situational factors such as organizational and informal support, and to a lesser extent, task characteristics. It also revealed that personality, attitudes, and competencies can influence the extent to which people engage in FBL. Equally important, it showed that demographics (e.g., age, gender) do not play much of a role. Our Year 2 correlational study extended previous research by showing how various factors can interact to influence FBL and subsequent performance.

Potential Army/Military Applications

It is imperative to 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. As we better understand what stimulates or inhibits FBL, we can target interventions to accelerate learning in the field. Based on our work to date, we will be designing and testing training to prepare individuals to learn more effectively when they are on assignment. We are also exploring ways to identify FBL needs and opportunities.

Eventually, it is our hope that this line of research will yield fundamental, innovative advancements in how the Army

views learning, assesses training needs, delivers training, and promotes FBL. New training needs, analysis methods, instructional design principles, and training techniques designed to accelerate FBL 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.

Future Plans

Year 3 will feature research that extends the Year 2 study by adding in quasi-experimental elements. Specifically, we will introduce and test potential FBL accelerants in the form of training and/or coaching. We anticipate that individuals who experience these accelerants will exhibit greater FBL, as compared to quasi-control individuals.

We also plan to develop a field-based learning analysis (FBLA) process by which the catalyst training can be contextualized and apply it in our sample population. In other words, we will develop more focused training pedagogy that will capitalize on enhanced knowledge of trainees and the situations that they will be deployed to, to provide deeper and better targeted strategies for enhancing FBL. Such techniques will be guided by a FBLA and incorporate instructional design principles, employ multiple training methods and tools, and be calibrated on the basis of trainee and trainer familiarity with the field situations, along with features of those situations (i.e., richness and malleability).



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

Contract #: W5J9CQ-12-C-0046
PI: Stephen G. Harkins

Contract Dates: 25 SEP 2012 – 24 JUN 2016
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 (the 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. So, 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 great deal 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 have conducted experiments that: (a) test core claims of the TIPPR Model; (b) 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 (c) 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

Based on the use of portable physiological recording devices (heart rate, respiration rate, and galvanic skin response), a previously validated set of assessment measures (cognitive, perceptual speed, and psychomotor abilities), skill acquisition, and sustained performance measures, the goal is to triangulate the ebb and flow of individual effort levels, performance, and subjective experiences of effort, perceived fatigue, and stress. Additional investigations will focus on whether physiological markers anticipate or follow performance and subjective estimates of effort during stress, engagement, and fatigue conditions. From these data, individuals will be classified in terms of over-responders (people who have large fluctuations of physiological markers for effort allocations), normals, and under-responders (people who evidence minimal physiological reactivity to task demands). In this research, we have conducted 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 are using a virtual



ball-bouncing task in which participants are asked to stand in front of a large back 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. 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). Thus, instead of simply manipulating the independent variable, threat, and seeing its effect on the dependent variable, accuracy in hitting a target line, we are able to examine each of the variables that mediate the performance outcomes.

Accomplishments

In the second year of the contract, we conducted experiments to: (a) test a core claim of the TIPPR Model that it is the perception of threat that potentiates prepotent response, rather than the motivation to perform well, which plays a role later in the process and only when the participant knows that the prepotent response is incorrect; (b) test the TIPPR Model against a popular current alternative account, working memory deficit, using the test bed of modular arithmetic; and (c) extend the analysis from cognitive tasks to a novel, sensorimotor task, showing that the effect of threat on performance can be predicted by examining the control mechanisms in this task.

The mere effort account argues that it is the motivation to perform well that potentiates prepotent response, whereas the TIPPR Model argues that it is threat that does so. Motivation to perform well plays a role later in the process and only when the participant knows that the prepotent response is incorrect. This analysis suggests that the fact that stereotype threat (ST) facilitates the performance of females on solve-type GRE-Quantitative problems is the result of threat alone, not the fact that the females are motivated to perform well. Thus, a threat that is completely unrelated to gender differences in performance on the GRE-Q

(e.g., ostracism) should produce the same pattern of effects as ST (facilitation on solve-type problems, but debilitation on comparison-type problems), but for males as well as females. This prediction is completely nonobvious, but follows directly from the TIPPR Model. This research has been completed and analysis is underway.

Previous research (Seitchik & Harkins, 2013; Contract Experiment 4) suggests that the prepotent response on the subtraction portion of horizontal modular arithmetic problems is to use the method of adjustment (MA) (adjust the subtrahend to the nearest 10, subtract the two numbers, add the adjustment). However, the traditional method (TM) (borrow from decades to perform units subtraction), which is used more by non-threatened females, may be more efficient, suggesting that threatened females perform more poorly than controls because they use a less efficient method. In Experiment 6, we found that with no instructions, we replicated the finding that control females outperform females under ST, but, overall, participants solved more problems using TM than MA, and holding solution approach constant, threatened participants outperformed controls, supporting the TIPPR account over a working memory account.

Previous ST research on sensorimotor performance has relied on measures that show the overall effects of ST on motor performance, but do not identify the relevant control mechanism(s). Huber et al. (2014: Contract Experiments 8 and 8a) showed that ST leads to greater error on a virtual rhythmic ball-bouncing task because ST potentiates an incorrect prepotent tendency, hitting with positive acceleration. In the current work, a task analysis of the control mechanisms in a novel, virtual single bounce paradigm revealed that the participants' prepotent response fell within the solution manifold defined by racket velocity and position (i.e., the prepotent response was correct). In the absence of this analysis with which we identify the prepotent response, we

would have no way to know whether ST would facilitate, debilitate, or have no effect on performance on this task. In a subsequent experiment, consistent with the TIPPR account, ST females outperformed no threat females, whereas ST and no threat males did not differ.

Contributions to Basic Research

A survey of the psychological literature reveals six different research traditions that have found that social threat affects task performance: social loafing, social facilitation, goal-setting, intrinsic motivation/creativity, stereotype threat, and achievement-goal theory. Although these traditions have proposed processes that could account for these effects (e.g., focus of attention, working memory deficits, withdrawal of effort, drive theory), the models do not agree on the mediating process(es), nor is there any compelling evidence favoring one account over the others. In fact, the same set of potential explanations proposed to account for the effects of social threat on performance has been with us for more than 100 years. For example, Triplett (1898) suggested "brain worry" as one explanation for his findings, which reappeared as "cognitive interference" in the 1980s (e.g., Bond, 1982), and is now termed "working memory deficit" (e.g., DeCaro, Thomas, Albert & Beilock, 2011). Another explanation, range of cue utilization (Eastbrook, 1959), that was used by Geen (1976) and Baron (1986) to account for performance effects, remains with us, but is now termed "focus of attention" (e.g., Muller & Butera, 2007).

The TIPPR Model has the potential to integrate research across these areas by suggesting a common process through which threat affects performance. In addition, the model suggests that this process can be located within a more general model of reactions to both social and physical threat. In addition to



contributing to our basic understanding of the effect of threat on task performance, this work also has the potential to lead to applied behavioral research that will produce more effective behavioral technologies, thereby improving the performance of Army personnel. Effective task performance is essential to the success of our armed services. However, in many cases, the tasks are performed under threat. Knowing the specific processes that mediate the effects of threat on performance is required both for effective training and for the design of effective intervention strategies. For example, the steps that one would take to counter the ill effects of potentiated prepotent responses are quite different from the ones that would be taken to counter the effects of working memory depletion. This research also demonstrates that a more sophisticated understanding of task characteristics is required for effective interventions to be designed. For example, simply knowing that a task is “complex” does not tell us what effect threat will have on its performance. The TIPPR Model has the potential to do exactly that.

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 third year, we will conduct additional research that tests core claims of the model, specifically the claim that physical threat will have the same effect on performance as a social threat. We will continue pitting the working memory account against the TIPPR Model using a new task, the Tower of London, which will allow us to pit the accounts against each other on an item-by-item basis. In Year 3, we will also continue our research on the sensorimotor task, virtual ball bouncing.

Before we developed the single bounce paradigm and analyzed the control mechanisms on this task, we had expected stereotype threat (ST) to debilitate performance on this task. However, our analysis of the control mechanisms showed that we should expect facilitation, which we then found when we examined the effect of ST on task performance. We are now examining the effects of manipulating various task parameters on the control mechanisms governing performance on this single bounce task, with the aim of finding conditions under which ST should debilitate performance.



LEADER DEVELOPMENT

DR. STEFANIE A. PLEMMONS, 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). Soldiers will also face increased time at home station compared to the last 10 years, requiring an understanding of how leaders can 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 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 to 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:
leadership processes, leader development, and 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, interpersonal, and resiliency-related skills) that underlie effective leader influence. Additionally, the program 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. The program also aims to develop theory and methods related to leadership located within networks and systems.

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, learning from both positive and negative on-the-job experiences, and developing strategic thinking and mission command skills, including the development of trust, cohesion, and shared cognition among subordinates. The development of leader identity is also of top priority. Moreover, the program seeks to develop theory to understand how implicit theories of leadership impact sensemaking, the impact of shocks to development, and gain and loss cycles in leader development. The retention of quality leaders is also of importance.

Leadership Assessment

ARI's Basic Research Program strives to develop measurement techniques to objectively measure effective and ineffective, verbal and nonverbal leader behaviors. The program also endeavors to develop theory and methods related to ways leaders seek and integrate feedback.



LEADER DEVELOPMENT

DR. STEFANIE A. PLEMMONS, RESEARCH PORTFOLIO LEAD

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 35-45.

Specification of Effective Mentoring Behaviors for Leadership Competency Development and Adaptability

(W5J9CQ-12-C-0040; 2012-2016)

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.

Emotion, Attentional Control, and Performance

(W5J9CQ-12-C-0035; 2012-2017)

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

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

(W5J9CQ-12-C-0029; 2012-2017)

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 as motivation and personality, and career/work outcomes associated with developmental reflection.

A 15-Year Extension to the Baseline Officer Longitudinal Development Study (BOLDS)

(WP11NF-13-1-0440; 2013-2018)

Dr. Bruce Avolio (University of Washington) is extending the BOLDS project initiated at the U.S. Military Academy in 1994 through 2015. Data will be collected to further evaluate how members of the class of 1998 have developed and how they currently perform in leadership roles. The research seeks to examine early antecedents that predict ethical, authentic, adaptive, and effective leaders.



Specification of Effective Mentoring Behaviors for Leadership Competency Development and Adaptability

Contract #: W5J9CQ-12-C-0040

PI: Lisa M. Finkelstein

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

Contract Dates: 28 SEP 2012 – 27 APR 2016

Institution: Northern Illinois University

Although much research has been done in the past few decades to link mentors' enactment of mentoring functions to career success outcomes for mentees, there has been virtually no examination of the most appropriate mentoring behaviors underlying these functions. The current project seeks to understand what good mentoring looks like at a specific behavioral level. Content analysis of 28 semi-structured interviews has led to the development of a taxonomy of mentor actions and objectives, highlighting the variation that exists in approaches even when objectives and actions are consistent. This taxonomy may prove useful for future efforts to train more effective mentors.

There is a growing need in both civilian and military contexts to develop effective leaders who can adapt to quickly changing environments. Leadership development efforts that strategically capitalize on informal learning opportunities are particularly necessary. An example of these efforts, mentoring, is a developmental relationship between a more experienced mentor and a less experienced organizational member referred to as a 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 mentoring functions (e.g., career support or psychosocial support) to career success outcomes for mentees, 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 a *specific* behavioral level

limits our understanding of the mentoring process and our ability to identify and/or train mentors. There is a 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 even harmful mentors?

Our project is looking 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 likely 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 identified 28 experienced mentors across industries, sampling men and women who mentor both informally and in the context of formal mentoring programs. Mentors were selected for participation in interviews if they had been identified as having a reputation in the organization for effective mentoring. We conducted semi-structured interviews, asking them to describe specific episodes in which they had an impact on their mentee, and then focusing on what exact behaviors they performed during those episodes. We transcribed all interviews and have been coding and analyzing transcriptions to identify mentor actions, mentor objectives (for actions), and contingency factors that may affect their behavior choices. Subsequently, we will validate this taxonomy in a study of other mentors and across multiple organizations. This survey research will empirically link mentor actions to mentoring objectives while accounting for the effects of several contingency factors such as mentee characteristics or organizational environments.

Accomplishments

In Year 1, we conducted two literature reviews and began interviewing expert mentors. The first literature review gave us a comprehensive picture of how "mentoring behaviors" have been defined and measured in the literature. As we expected, this term was defined loosely and not specifically enough to clearly envision or replicate a behavior. The second literature review identified typical outcome variables used in the mentoring literature and confirmed that adaptability had not been sufficiently explored.

Interviews of 28 expert mentors were completed in Year 2. These were semi-structured interviews requiring the mentor to think of specific mentoring episodes and answer questions to isolate



specific behaviors and contingencies that occurred in those episodes. The interviews were transcribed and went through several levels of analysis as described below.

We initially coded mentors' descriptions of their behaviors into themes, leading to two discoveries. First, we gained insight into the level of analysis at which our theme coding was yielding information regarding specific mentor behaviors. These themes were more numerous and at a greater level of specificity than the descriptions of mentor functions commonly found in the literature, but we still believed they did not quite capture the nuanced levels of specificity of actions that we hope to be able to describe.

Second, themes emerging from our coding were of different types. Sometimes they were more descriptive of actions the mentors took, sometimes more focused on the mentor's objectives for those actions, and sometimes a combination of these. For example, some action themes include: "respond quickly with enthusiasm to mentee's first contact" and "help point out the weakest spot and ways to fix it." Themes that also included objectives with actions include: "help the mentee find events to attend for developmental purposes" and "ask practical questions to make sure mentee is prepared for an upcoming situation."

These discoveries led us to understand that effective mentors have a set of actions executed during mentoring for a number of objectives, and that there are multiple ways that general actions are specifically enacted by mentors when striving for one or more objectives. In other words, there could be several examples of what mentors did to "enact" the particular themes. This is a more complex characterization of mentoring behaviors than we initially anticipated and led us to a newer model of mentoring behaviors that can be envisioned more as a cube (see Figure 1).

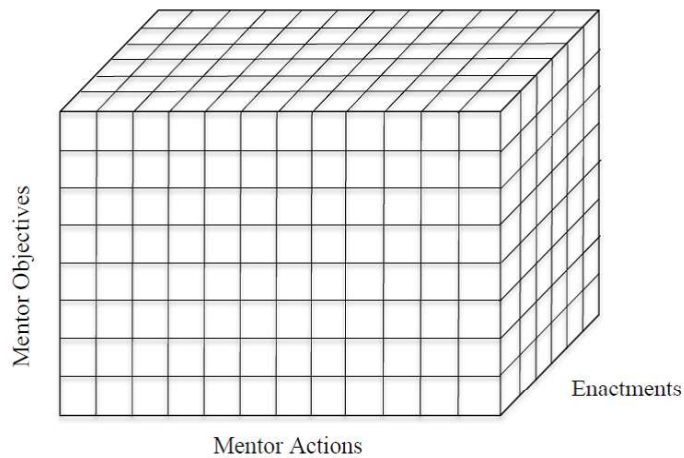


Figure 1. The cuboid taxonomy of mentoring conceptualizes the relationship between mentor objectives and leader actions and behavioral enactments.

This schematic led us to a second-stage coding procedure. Each theme emerging from the interviews is currently being coded by the team as to the action(s) described in the theme and the objective(s) implied by the theme. Following the completion of this process, the particular passages from the interviews that were coded in them will be paraphrased into unique enactments.

To illustrate, some example actions include "ask questions," "assess needs," and "provide advice." Some example objectives include "mentee competency development" and "build/expand professional network." Although only at the initial stages to date, an example enactment of providing advice (action) for competency development (objective) is "provide advice to mentee on writing a resume that highlights their accomplishments without compromising ethics by embellishing or fabricating information."

Contributions to Basic Research

An understanding of specific effective mentoring behaviors and objectives, derived through our literature reviews and behavior-targeted interviews with effective mentors,

advances basic science in multiple ways. First, while the mentoring literature has multiple taxonomies of mentoring functions, there is little clarity on specific behaviors or objectives. Mentoring functions tell us more about the goals that mentors are trying to achieve, rather than clarifying the specific approach they use to achieve those goals. Focusing on behaviors and objectives provides opportunities for future mentoring researchers to make more fine-grained distinctions in their theories of how mentoring works. Further, we look at mentoring in a new and unique way by separately classifying actions, objectives, and enactments, which will allow a finer-grained distinction to understanding the nuances of effective mentoring behaviors.

In the second phase of our research, we will examine the degree to which the enactment of common mentoring behaviors is determined by the objective of the behavior, characteristics of the mentor, characteristics of the mentee, and characteristics of the situation. This will further our understanding of the generalizability of effective mentoring behaviors and serve as a test bed for future studies of other characteristics toward the goal of determining the most effective approach to mentoring under various circumstances.



The enactments of mentoring that result from these tests could be used for the development of future measures of mentoring behaviors. A more precise measure of the nuances of effective mentoring will be a valuable tool to researchers developing new models of the processes of mentoring.

Finally, there is little research that has evaluated the success of different mentor training approaches and content on improving the effectiveness of mentors. Although creating training programs is beyond the scope of the current research project, the taxonomy of behaviors produced in the current research could be used to design and test alternative training content, derived from our specific behaviors.

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 understanding effective actions and objectives, the research can inform future interventions that directly benefit the military in general and the Army specifically. 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 actions and objectives.

Finally, many of the objectives of mentoring include the development of various competencies that are important to leadership in the military. One such competency 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, adaptive 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

Our immediate next step is to finish the second stage of coding of the expert interviews. This will result in a more complete understanding of objectives, enactments, and moderators of mentor actions. Subsequently, we will conduct an empirical study of the relationships among these three attributes. A pre-test with a small set of mentors will allow us to determine appropriate, easy-to-use rating scales by which mentors, in the full study, can communicate the effectiveness or value of specific enactments under specific circumstances. Next, we plan to have a larger set of mentors rate enactments as a function of mentoring objectives and under different levels of possible moderators. One moderator will be a mentee characteristic (e.g., mentee skill/experience) and one will be a situational characteristic (e.g., early relationship/established mentoring relationship). For example, a mentor might rate the effectiveness of enactment E1 for accomplishing objective O3 for an

inexperienced mentee early in a relationship. Mentor raters will then rate other combinations of enactments/objectives/moderators. The data will be analyzed using Generalizability Theory to estimate whether there is meaningful variance by:

- mentor (e.g., are there mentor styles?)
- enactments (e.g., are some enactments “better than others”?)
- objectives (e.g., do some objectives drive the choice of mentor behavior?)
- combinations of enactments, objectives, or conditions (e.g., does the value of enactments depend on the context?).



Emotion, Attentional Control, and Performance

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

Contract Dates: 28 SEP 2012 – 27 SEP 2017
Institution: Georgia Institute of Technology

Army leaders are constantly faced with emotionally-laden situations. Research on the effects of emotional states on performance remains inhibited by a predominate research paradigm that cannot easily accommodate fluctuating affective states and their concurrent influences on within-person changes in performance. The current set of studies informs a deeper understanding of the roles of emotions in the workplace, including how emotions influence attention through misallocation. The first study provides support for the natural segmentation of performance by individuals. Subsequent studies will build upon the first by examining boundary conditions for the influence of emotions on momentary performance.

A Soldier's life, work life in general, is rife with emotional experiences. It is obvious that these emotional experiences can influence critical performance, yet research on the effects of emotional states on performance remains fragmented. One 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 that 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. Deple-

tion 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.

Although previously laid out in theory, performance episodes have not been studied in a manner appropriate to capturing the ups and downs of momentary fluctuations in performance. One goal of our research was to create such a method—that allows us to jointly measure within-person fluctuations in other states, such as changes in emotions and attention, with changes in performance. As we continue our research, our objective is to use our basic understanding of episodic performance to further understanding of the performance experience. We will examine nuances of the performance episode, directing attention toward within-person changes in emotions and regulatory resources and assessing how these changes interact with task characteristics to influence episodic performance. In addition, chronic depletion of regulatory resources is expected to adversely influence one's general ability to focus.

Research Approach

This set of studies mostly uses the experience sampling method that surveys full-time employees at multiple times during the day. Individuals are prompted to report 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 are collected in order to validate self-reports of performance. Analyses are conducted using multilevel modeling to account for the nested structure of the data and the repetition of observation. Other studies 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.

Accomplishments

Our research to date has set the foundation for the rest of our proposed studies and verified and confirmed important foundational ideas. We have completed our initial study, which confirmed the critical idea that performance episodes can be identified and analyzed in relation to other episodic states, such as emotions. This study followed workers multiple times a day for 3 weeks to investigate the relationship between performance episodes and emotional states at work. As hoped, people were able to parse their workdays meaningfully into performance or task episodes and were able to rate their performance on those episodes. Substantially more than half of the variability in performance (69%) was due to changes within workers from one time to another, confirming the importance of looking at how and why performance fluctuates for an individual.

Importantly, we found that emotions predict episodic performance and that this process works through the effect of



emotions on momentary attention. As suspected, negative emotions led to a decrease in attentional focus and subsequent performance. However, positive emotions led to an unexpected increase in attention and successful performance. The results support the idea that it is the allocation and misallocation of resources that drives the relationship between emotions and performance. We are now preparing these results for peer-reviewed publication.

These findings are critical to the rest of our research plan. All other research propositions are based upon the ability to identify and measure performance episodes and having a technique to do so. The method created in our first study will be used in subsequent studies to investigate the effects of within-person changes in emotions and regulatory resources on performance.

In conjunction with our first study, we created a database of potential research participants. We keep information about people who are interested in participating in our research in a database that we consult when we begin a new study, allowing us to invite potential participants who qualify for our studies based on the characteristics (e.g., full-time) they have provided. The potential participants in our database are workers in various professions, providing a diverse occupational sample to study.

These accomplishments along with preparations for further studies have prepared us to begin more in-depth studies of performance episodes. We are preparing for a full investigation of the impact of chronic regulatory depletion (i.e., burnout) on attentional resources. For this study, we are currently contracting with a computer programmer to have mobile attention tasks created, so that we may incorporate objective measures of attention into an experience sampling study that will begin this fall. Two additional studies will assess the ability of task characteristics (i.e., goal type and task complexity) to mitigate the effects

of resource reallocation from emotional responses.

The studies will assess goals and task complexity as task characteristics that could draw attention to a task when emotions are pulling attention away from the task.

Contributions to Basic Research

This research contributes to the understanding of the episodic nature of performance and the effect of momentary affective states on this performance. In industrial-organizational psychology, performance has by and large been addressed as a stable trait of individuals. However, our projects suggest that information can be gained from examining performance as a time-varying construct, with individuals performing better or worse at given times, on given days, in given weeks. From our root project, we have successfully used a technique to capture the within-person variability of performance rather than providing a single average measure over a length of time (e.g., quarter, year). The ability for people to identify performance episodes as shown in our research validates the concept of a performance episode and is key to being able to study performance using a moment-by-moment approach. The large amount of performance variability that occurs within-person further highlights the need for performance research to move to a momentary, dynamic examination.

Much can be gained from a momentary perspective of performance. Examining performance as episodic leads to a variety of new research questions, such as what characteristics of the tasks, environments, individual's states, etc. affect one's immediate performance? As individual states vary, so, too, does performance. Both positive and negative emotions contribute significantly to within-person variability in performance

in different ways. This research suggests that momentary affect has implications for attention and immediate performance levels. Findings further highlight how little is known regarding the dynamic influence of emotions on momentary ability to perform one's task.

The above findings lead to an array of potential avenues for future research. Emotions undoubtedly contribute to one's momentary performance level. The next steps include determining what task characteristics may circumvent the attentional demand of emotions. Tasks of interest or importance should help maintain task-related attention in the face of distracting emotional states.

General resource levels may further contribute to momentary performance. Emotions, including the effort to control one's emotions, may drain one's ability to perform. Chronic levels of resource depletion, such as burnout, may lead to a greater difficulty in attending to tasks during the workday. The performance of burned out individuals may suffer more from emotional experiences than those who are not burned out, as the chronically exhausted individual has fewer resources to combat the distraction. Many research questions remain to be examined; the present findings are only a first step.

Potential Army/Military Applications

Army leaders 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 Soldiers. 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 a 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, and leader 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.

The 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, especially those relevant to leader decision-making processes. 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, in turn allowing the Army to train effective strategies for leaders to manage and mitigate Soldier emotional influences.

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 emotions and performance as they happen.

Future Plans

Now that we have established the relationships among emotion, attention, and performance, we are following up with issues related to emotional regulation and regulatory resource depletion. We will conduct a 2-week experience sampling study, investigating the extent to which chronic depletion, or burnout, makes it more difficult to ignore distractions and remain focused on work tasks. Higher levels of burnout are expected to be related to lower levels of regulatory resources, indicated by poorer focus at work as well as poorer performance on tasks assessing general attentional capabilities and less civil behavior displayed in the workplace.

During the year, we will also investigate the ability of task characteristics to hold attention in the face of emotional events. Two experimental studies will soon be underway to examine this relationship. In the first of these studies, we will look at the ability of task complexity to retain attention when a situation of reward is unjust. We expect that tasks requiring greater cognitive resources will override the potential cognitive interference that would come from an unfair outcome. Likewise, we expect in our second study that goals will retain attention on the task in spite of emotional reactions from being left out of a social situation. We expect that difficult, but attainable, goals will draw attention to the task even when an emotional response to ostracism is evoked.

In addition, we will conduct an experience sampling study that examines the effect of emotional regulation activities throughout the day on objective measures of attentional control. We expect that those who report more self-regulation activities, such as holding back one’s emotions, will show decrements in tasks designed to measure attention.

Associated Publications

Merlo, K. L., Plemmons, S. A., & Weiss, H. M. (2014, May). *The impact of emotion states on performance episodes*. Poster presented at the Annual Convention of the Association for Psychological Science, San Francisco, CA.

Weiss, H. M. (2014, May). Panelist. In S. L. Fisher and K. A. Orvis (Chairs), *Beyond the subject pool: Creative sampling methods in I-O research*. Panel discussion conducted at the Annual Conference for the Society for Industrial and Organizational Psychology, Honolulu, HI.



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: 28 SEP 2012 – 27 SEP 2017
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 directly addresses the previously ignored role of reflection in relation to predictors and outcomes of learning. This research project first develops and tests a new measure and then conducts a longitudinal study and a field experiment to examine the effects of a reflection induction/intervention designed to increase reflection behavior over time. The constructs and associated assessment methods developed in this project may 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 upwards 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.

The present project directly addresses reflection in some detail, examining it in relation to predictors and outcomes. At the conclusion of this project we expect 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 includes two parts.

1. An effort to discover the nature of reflection and its makeup through inductive and deductive approaches, develop the new measure content, and pilot test these materials.
2. The main longitudinal study in which the new individual difference measures are tested over time and in relation to other variables. This field experiment also examines the effects of a reflection induction/ intervention designed to increase reflection behavior over time (see Figure 1).

Accomplishments

As described above, the research design includes two parts (i.e., develop new measure content and the main study).

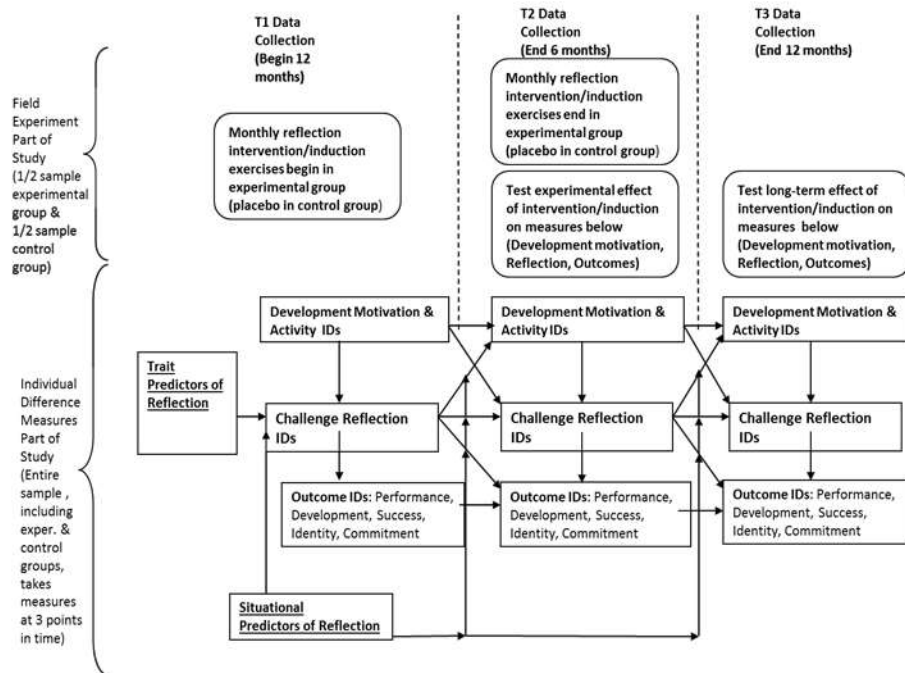


Figure 1. Organizing conceptual model and research design overview.

which the reflection scale and induction tool were developed:

- (1) *What/why of reflection, or the triggering problem or challenge component;*
- (2) *How reflection works, or the explain-analyze-confirm component; and*
- (3) *The implications, or the plan for action and future change (e.g., “Now what”) component of reflection.*

In this pilot, we conducted two empirical studies that were designed to: (a) explore initial/preliminary psychometric characteristics, and (b) provide an initial test of a reflection writing exercise or induction tool designed to guide and focus reflection on challenging experiences to be used in the main study (the upcoming phase of the project). The new scales had adequate psychometric characteristics for proceeding with a more complete and thorough validation in the main study as intended according to the project plan. Minor improvements or refinements were made prior to that upcoming study based upon the results observed in the pilot.

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 develops and tests 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, and human resources.

The first part of the project has been completed; that is, developing theoretically- and practically-grounded measures and induction of the reflection behavior. To ensure good coverage, this was based upon a review of the theory and practice literature as well as an open-ended research study of the content and process of reflection.

A major accomplishment during that period was to complete a study of how people naturally reflect. This was done via open-ended survey questions and interviews that focused on the manner in which people engage in reflection on challenging experiences related to work. The data from the open-ended study shed light on how the respondents reflected, not on how they should reflect for maximum developmental benefit. The trends revealed were descriptive and not prescriptive. We, therefore, also examined the research literature on reflection, after event reviews, and employee and leadership development.

Based upon both of these sources (open-ended study, literature review) we prepared a draft of new measures and a reflection induction tool (writing exercise to shape reflection), and then conducted a pilot study to examine participants’ initial psychometric characteristics prior to beginning the main study, or “Part 2” of the present project.

The main goal of this first stage of the project was ensuring good coverage of critical parts of the construct space when developing new measures of reflection behavior in relation to challenging experiences at work. This includes a combination of deductive (ongoing literature review) and inductive (open-ended questions) approaches to model development and measure generation.

In this project, three main aspects of reflection on challenging experiences—in terms of both process and content—were identified. These three were included as the major measurement categories around



Leadership

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

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 is relevant to training design, including identifying training principles and theory that can be used to refine technologies. The present project involves 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 settings and more 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 those Soldiers and leaders who will be most effective at drawing the greatest development from challenging experiences they face on duty. These tools are new, not previously examined in the research literature, and applied in a manner that breaks 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 is directly relevant to these key human resource concerns.

Future Plans

We will initiate the main project, consisting of (a) a longitudinal study of new individual difference measures in relation to other constructs, and (b) a field experiment that examines effects of a reflection induction/intervention to increase reflection behavior. Figure 1 provides an organizing conceptual model and research design overview that provides a graphic preview of the main study.

There are several parts to the main portion of this project that will be initiated during the next year: (a) a recruitment of matched pair cases (respondent and his/her supervisor from work), (b) a longitudinal 3-wave survey over 12 months, and (c) a written exercise done by each participant (not supervisor) several times during the first half of the 12-month period. The respondent will provide data on the new reflection measure as well as on the predictors and outcomes over time, while the supervisor will provide data on the respondent's job and development be-

havior (outcomes). The written exercise is the reflection guide or induction tool that is meant to influence or manipulate the way the respondent reflects over time.

Associated Publications

Maurer, T., Corner, A., Hardt, G., & Leheta, D. (2014a). *Developmental reflection as individual difference: A model of predictors and outcomes in leadership development*. Presented at the annual conference of the Southern Management Association, Savannah, GA, November.

Maurer, T., Corner, A., Hardt, G., & Leheta, D. (2014b). *Development of measure content and initial exploration of psychometric characteristics*. (ARI Interim Progress Report). Ft. Belvoir, VA: U.S. Army Research Institute for the Behavioral and Social Sciences—Foundational Science Research Unit.

Maurer, T., & Leheta, D. (2013). *Content and processes underlying reflection following challenging experiences: An exploration using open-ended survey and interview questions*. (ARI Interim Progress Report). Ft. Belvoir, VA: U.S. Army Research Institute for the Behavioral and Social Sciences—Foundational Science Research Unit

Maurer, T. & Leheta, D. (2014). *Reflection on challenging experiences: An exploration of content and process*. Presented at the annual conference of the Southern Management Association, Savannah, November.



A 15-Year Extension to the Baseline Officer Longitudinal Development Study (BOLDS)

Contract #: W911NF-13-1-0440
PI: Bruce J. Avolio

Contract Dates: 30 SEP 2013 – 28 MAR 2018
Institution: University of Washington

Leader development is a process occurring over time. Longitudinal research efforts are necessary to meaningfully examine development. The West Point class of 1998 presents a unique opportunity to assess leader development from a longitudinal context. The present study aims to extend the existing dataset, updating data to capture the current career span of the class. Extending the database enables an examination of the impact of experiences, such as education, life, and career events, on leadership emergence and one's success in leadership roles. Additionally, reflection by participants will allow for an understanding of the most pivotal events in one's development as a leader.

In this longitudinal study, we will extend the Baseline Officer Longitudinal Development Study (BOLDS) Project initiated at the United States Military Academy (USMA) in 1994 through 2015. Building on the original BOLDS investigation and the work we have done over the last few years to organize the database, our goal is to continue data collection to further evaluate how members of the class of 1998 have developed and how they currently perform in leadership roles more than 15 years after graduation. We will collect additional assessments of leadership with measures not available at the time BOLDS was initiated in order to examine the participating leaders' growth and development.

The first phase of the extension to BOLDS involved building a comprehensive database that included all data collected thus far from the class of 1998. In this next phase, we will collect assessments of leadership and performance in the BOLD participants' current position, as well as collecting data on events that have shaped their leadership development over time. Ultimately, we will focus on examining early antecedents that predict the most ethical, authentic, adaptive, and effective leaders and how they have

grown as leaders since their time at West Point.

The BOLDS database includes numerous predictors, such as early leadership and life experiences, leadership style in the USMA, and other predictors of leadership development. There are relatively few leadership studies that have the advantage of collecting predictors and performance data over such extended periods of time where we can study leadership at the highest ends of performance domains: for example, performing in extremely challenging contexts, such as in the various deployments of our military officers. Also, the longitudinal framework for this proposed study provides opportunities to assess growth, change, and development in leadership, particularly with the collection of new data. Another unique feature of BOLDS is that all participants started their careers at the same time, in the same institution, and entered into the same ranked leadership position. One of the goals of this project is to enlist BOLDS participants to continue this longitudinal study to further examine their growth and leadership potential now, more than 15 years after their graduation from USMA.

Research Approach

There are three strategies that comprise the analytical approach we are using for the BOLDS project. The first involves conducting a longitudinal field investigation where we are examining early antecedents to leadership emergence and performance. Secondly, we will examine how various events in the participants' lives over the past 15 years have impacted their motivation to lead and their leadership styles and performance. The third area of inquiry will involve examining leadership growth and change. We will use a mixed methodological approach to capitalize on the strengths of both qualitative and quantitative methods.

Contributions to Basic Research

This research aims to contribute to research by generating an increased understanding about how individual differences and events impact and predict leadership development and success over time. The longitudinal nature of the study provides us with the ability to examine how experiences, including pre-academy experiences as well as educational, life, and career events over the past 20 years, have impacted leadership emergence and success in leadership roles of USMA graduates. Additionally, using a multi-method approach, the study will allow us to analyze reflections of participants to identify which of these experiences are perceived to be most pivotal in their own development as leaders.

This research will look at how individual differences, such as intellectual ability, personality, self-confidence, logical reasoning, and other personality characteristics predict changes in self-awareness, self-identity, logical reasoning, and leadership style. We expect these results to add to our understanding about the individual differences that are



most closely related to and predictive of success in leadership roles. Additionally, this study includes multi-rater feedback from peers, supervisors, and followers of the participants, which will be analyzed to create a better understanding as to how leaders interact with their colleagues and how these interactions impact leadership development and performance.

Potential Army/Military Applications

As a result of this research, we expect that the Army will obtain detailed information about what predicts the development of effective officer leaders. The ability to examine how the early leadership experiences at the United States Military Academy fostered development of leadership later in Soldiers' careers is an important advantage of the BOLDS project. For example, we have the leadership positions held by the cadet officers prior to and while at West Point, allowing us to examine how being involved in certain activities and positions may have shaped the cadets' leadership development. We also will work to obtain more recent experiences that shaped the BOLDS participants' development (for example, engagement in extreme contexts, such as being deployed in Iraq, Afghanistan, or elsewhere). With BOLDS, we have the data to examine how unique profiles of individuals, in terms of personality or earlier leadership styles, predict subsequent leadership and performance over an extended period of time. We also have the opportunity to collect data on the BOLDS participants' reflections of what they consider to be pivotal events in their leadership life span that have impacted how they lead and their success in leadership roles.

Some specific applications include:

- The identification of unique development opportunities that help to predict ethical, abusive, effective,

adaptive, and transformational leadership styles.

- An understanding of how critical life/career/educational events that have occurred, either within the military experience or outside of the military, can directly influence leadership growth and development over an extended period of time.
- An understanding of how intellectual ability, personality, self-confidence, logical reasoning, and other personal characteristics predict changes in self-awareness, self-identity, and leadership style in the USMA and after graduation, in active military service or outside the military context, for those who left the Army.
- An understanding of how personal characteristics and/or types of events contribute to successfully performing in extreme performance contexts.
- An understanding of how leaders interact with superiors, colleagues, and followers, and the impact those interactions have had on their leadership development, potential, and performance.
- An understanding of how each of the above predicts leadership effectiveness for those BOLDS participants who have left the military and are in the private or public sector.
- An understanding of how pre-academy experiences, education, and life events predict long-term success in leadership roles over a 15-year time span.

Being able to now look back from their current positions of leadership, BOLDS participants can provide a better understanding of the experiences at the Academy that were pivotal to shaping their leadership development. In addition, we will be able to examine how their first assignments, as well as the leadership support they experienced, shaped their future development and performance.

Future Plans

In Phase 2 of this project, upon approval of the IRB packet, we will collect additional data from the BOLDS participants using web-based survey measures. Our research team will work to finalize an up-to-date data base of contact information and establish connections with BOLDS participants, both those who have left the military and those who have stayed, to begin follow-up with both groups. Specifically, we will collect self-report survey data on participants' leadership life histories, as well as self-report assessments of areas relevant to their leadership, such as their self-confidence as a leader, willingness to help others at work, confidence in handling ethical matters, approach to self-development, and resilience. We will also ask participants to provide us with a list of raters who can evaluate their current leadership style. This will give us data to investigate how far they have come since their time at West Point and which factors may have helped or hindered their development. We also will solicit BOLDS participants' continued involvement in this longitudinal research project, in order to continue to evaluate their growth and development over time. As we build out this data set in the future, it will provide us with incredible insights into the ongoing process of leadership development.





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:
organizational processes and dynamics, multi-level methods and models,
and organizational theory.

Organizational Processes and Dynamics

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 multi-level constructs that incorporate unobtrusive approaches and are useful for detecting and understanding variation in relevant time frames. 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 four extramural research projects.

Brief descriptions of the contracts are provided below, with detailed research summaries of each contract provided on pages 49-61.

Tracking and Shaping the Language of Working Groups

(W5J9CQ-12-C-0043; 2012–2016)

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 to use such measures to provide real-time feedback to individuals and groups.

Understanding Network Socio-Geographic Dynamics: Using Smartphones to Locate, Track, and Study Goal-Directed Team Behaviors

(W15QKN-13-C-0090; 2013-2017)

Dr. Kevin Curtin (George Mason University) and colleagues are utilizing a multi-disciplinary approach to investigate goal-directed behavior of teams and multi-teams in geographic space.

A Computational Modeling Approach to Organizational Effectiveness: Mapping the Effects of Leadership, Group Structure, and Environmental Shocks

(W911NF-14-0026; 2014-2019)

Dr. Steve Kozlowski (Michigan State University) and colleagues are employing a novel research approach using computational modeling to conduct virtual simulations that will enable full exploration of a meaningful theoretical space relevant to the focal phenomena.

The Development and Construct Validation of Unobtrusive Dynamic Measures of Team Processes and Emergent States

(W911NF-15-1-0014; 2014-2019)

Dr. Scott Tannenbaum (Group for Organizational Effectiveness, Inc.) and colleagues are developing new methods for classifying, measuring, and using complex data from teams and groups to understand group processes.



Tracking and Shaping the Language of Working Groups

Contract #: W5J9CQ-12-C-0043

Contract Dates: 12 SEP 2012–30 APR 2016

PI: James W. Pennebaker

Institution: The University of Texas at Austin

Co-PI/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 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 have focused on the Input portion of the model. Studies on group size, composition, role structure, context of the group, and so forth 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, and so forth.

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:

- identifying the basic coordinating mechanisms of a working group,
- agreeing on good measurement strategies that reflect relevant group processes, and
- 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 called TOWER (Texas Online World of Educational Research) for testing and in-class discussions. The TOWER platform regularly creates task-oriented, online group interactions consisting of 2-30 people. The platform not only facilitates the current group dynamics research in a methodological sense, but allows for the wholesale collection of data relevant to group processes. Additionally, each group’s interactions can be analyzed by a word counting software, Linguistic Inquiry and Word Count (LIWC), within the TOWER system and manipulations of group dynamics can be delivered using this information. 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 in order 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. New results from this approach will inform our understanding of how groups work, what facilitates/hinders group success, and how these factors can be altered in real time.

Accomplishments

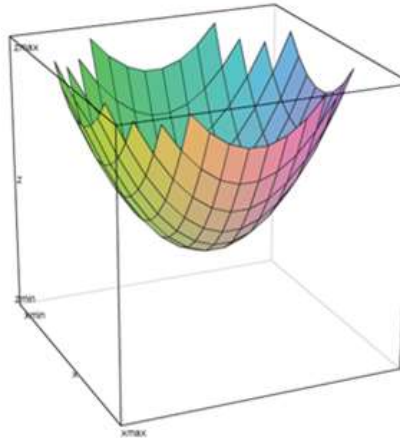
Central to the project is the understanding of how groups work in learning environments. Across the Fall of 2012 and the Fall of 2013,



we collected data from more than 2,000 students enrolled in the TOWER course. These data include relevant psychological measures of each individual in the course and complete behavioral data for more than 5,000 separate group interactions. Multiple lines of analytic procedures have commenced that combine data from both classes, and advanced data mining procedures have commenced with regards to group processes and outcomes. Additionally, multiple software/algorithm creation projects have completed an initial development cycle and are being employed for the purposes of data extraction and analyses.

Early analyses have been primarily focused on gaining a concrete understanding of what processes actually exist in the course of a group interaction. Thus far, we have been finding that there are several reliable linguistic markers of different group processes. For example, we have begun a thorough exploration of how a single group member may individually and subtly contour a group's processes and subsequent performance in a positive ("boosting") or negative ("bombing") direction (see Figure 1). People who tend to boost a group's effectiveness and engagement often tend to possess language that is indicative of specific thought process-

"Boosting" Concept



"Bombing" Concept

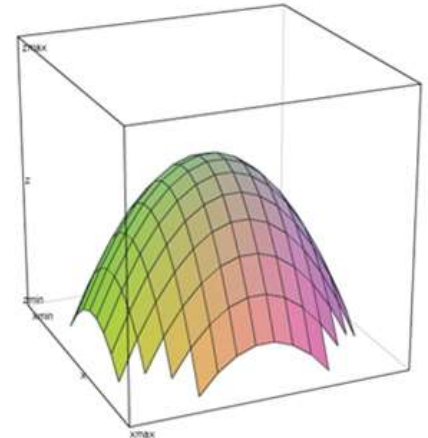


Figure 1. A visual depiction of the "boosting versus bombing" concept.

This figure depicts the idea behind analyses exploring "boosting" and "bombing." On the left, imagining that the inverted cone represents a group's cohesion and performance. In this case, a group member would be "boosting" the rest of their group members by driving up positive group attributes, processes, and behaviors. On the right, a group member is "bombing," effectively doing the exact opposite of a "booster."

es, such as making appropriate conceptual distinctions and matching the linguistic styles of others, as well as less overtly social language (language pertaining to one's friends, family, and others).

Importantly, by studying the language of individuals who show a tendency to "boost" a group, we are able to predict the degree to which a group's composition will influence its cohesion and performance prior to its formation (see Figure 2). The way this is achieved is by tracking each individual across multiple group interactions to calculate how much they tend to have a positive influence on group process-

es. Analyses at this level are revealing that "seeding" a group with boosters may be beneficial insofar as they possess linguistic characteristics that impact other group members in a positive manner. When groups are composed of people with the linguistic profile of boosters, these groups tend to be more behaviorally engaged, report greater cohesion, match each other's linguistic styles more, and group members tend to exhibit improved performance on later tasks.

Other analyses in our lab are showing some success in creating a computationally lightweight method for exploring the degree to which members of a group are staying on task and, at a basic level, discussing the same subject matter. Early results in this area are finding that there are two distinct ways in which group members may be closely engaged with

Group Cohesion

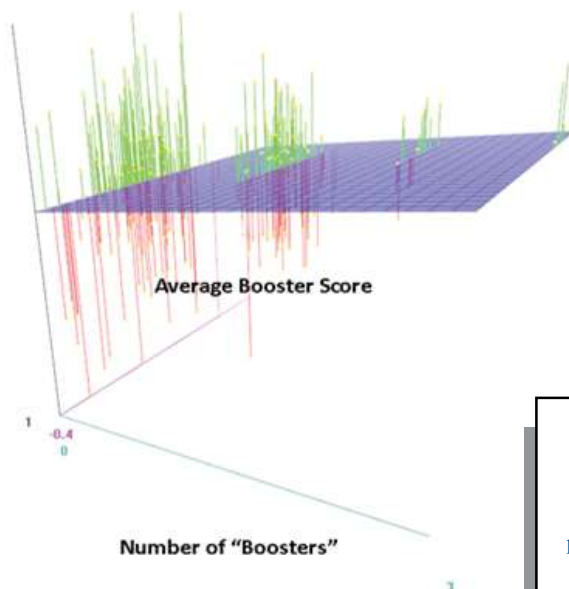


Figure 2. Predicting group success based on its composition.

This figure depicts the degree to which a group may be successful based upon its composition of "boosters" and "bombers." The figure shows that as the number of "boosters" in a group increases (in addition to how strongly they have "boosted" their past groups), a group's cohesion reliably increases, as shown by the rising purple plane.



each other: stylistically and in terms of content. The importance of these findings is that the two ways group members engage each other show only modest overlap, and is predictive of quite different things. For example, stylistic matching appears to be related to factors such as a person's gender, performance, and openness to ideas, whereas content matching appears to show stronger relationships with a group's cohesion, conscientiousness, and lower levels of individual-level psychopathy.

Contributions to Basic Research

Theoretical Contributions to Basic Research

The current project will make considerable contributions to the existing theories of group dynamics, behavior, performance, and functioning from a process-driven perspective. A core facet of the way that groups function is through the verbal mode of communication, especially in modern contexts that rely heavily upon computer-mediated communication for the education and training of large numbers of individuals. However, empirical research in this realm is currently lacking, as is our general understanding of the processes by which groups may become successful as interactions occur in a procedural fashion. Our research in this realm is beginning to elucidate the various language-based factors that contribute to the inner workings of a group, namely, how groups may come to perform at various levels as a result of the meaningful sharing, creation, and promulgation of language-based information. Theoretical implications from this work are, firstly, an unprecedented look at how groups function in a manner that is rigorous, valid, and reliable. As virtually no solid empirical research exists in the realm of the current project, we are quite literally creating new theories of how groups function with every analysis.

Pragmatic Contributions to Basic Research

An ancillary consequence of this research project is the creation and eventual distribution of various software, algorithms, and tools that may be adapted to research purposes beyond those proposed within the current project. Software and algorithms related to group interactions may be broadly applied in research methodologies for disciplines interested in topics such as (but certainly not limited to) relationships, dyadic interactions, communications, human-computer interaction, data mining, education, behavioral shaping, performance, and clinical outcomes. Some tools generated in the context of the current project will also serve to facilitate data analyses with popular statistical packages, such as R, which is currently used by researchers in virtually all quantitative fields of inquiry.

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 10 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 specific regards to our analyses and results thus far, the potential applications to military training are quite profound. Given that Army/military procedures are largely social in nature and may typically involve groups of varying sizes, identifying impactful features of group members through their language is a powerful prospect looming on the horizon. Perhaps one of the most relevant results is that involving the "boosting vs. bombing" concept. By monitoring language, both inside and outside of group contexts, it may be possible to identify those individuals who would be best suited to disperse among different groups to "seed" group cohesion and later group performance. Relatedly, it may be possible to identify individuals who show linguistic proclivities of "bombers"—that is, those individuals who may need additional or different training to become a more positive influence on a group's processes.

Our early analyses of how group members engage with each other on a one-to-one level in terms of stylistic and content similarity also show promise for application to group scenarios in the military. While stylistic similarity is relatively automatic, content matching may be more malleable and accessible to those overseeing group training exercises. By focusing on both stylistic similarity and the previously poorly-studied content matching indices being developed in our lab, groups may be able to be optimally trained to interact, thereby setting the stage for smooth and effective future group interactions and enhanced individual-level performance outside of the group setting.



Final Summary

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.

Work under the current contract will continue to develop in terms of scope and analytic capabilities. Across the duration of the contract, the primary focus of the research will be in educational settings where the primary goal is to maximize the individual performance of group members, with a secondary goal of improving group performance of ailing or ineffective groups. 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.



Understanding Network Socio-Geographic Dynamics: Using Smartphones to Locate, Track, and Study Goal-Directed Team Behaviors

Contract #: W15QKN-13-C-0090

Contract Dates: 30 SEP 2013—29 SEP 2017

PI: Kevin M. Curtin

Institution: George Mason University

Co-PI/Subcontractors: Richard M. Medina, George Mason University; Alec D. Barker, Group W Inc.

No fundamental empirical research exists to describe the goal-directed behavior of teams and multi-team systems in geographic space. This research draws from extant research, and applies statistics and methods, from among multiple disciplines including geography, sociology, network science, systems engineering, and strategic studies to develop new testable hypotheses, produce an empirical baseline, and evaluate some propositions about the socio-geographic behaviors of discrete social networks. Results will provide new metrics, defensible hypotheses, and randomized, empirical, and theoretical distributions of observations to support new research in societal instability, criminology, radicalism, social psychology, and simulation of stochastic human geographic processes.

Intelligence approaches to the problems of terrorism, insurgency, trafficking, organized crime, and political subversion demand methods to discern and interpret spatial patterns of activity associated with teams pursuing illicit goals while operating freely among a population. Analysts use terms such as “autonomous cells” and “leaderless resistance” to characterize these teams as discrete social networks that are united by common objectives, even though they may operate in a decentralized manner and work towards disparate tasks. Behavioral scientists, especially organizational psychologists, have studied team motivation and performance for many decades and produced sophisticated models of goal-oriented collective activity. Significantly, research focused on the interdependence of teams under conditions of decentralized authority has produced the concept of multiteam systems. The multiteam systems concept may help explain the behaviors of politically subversive groups. While there is a rich theoretical literature to describe the forms, functions, and functioning of

teams, and while there are also numerous examples of theory-driven models of human competition, there is no fundamental empirical research to describe how teams and multiteam systems, especially clandestine teams, actually pursue goals in geographic space.

This program of basic research explores the geographic behaviors of teams pursuing group goals in order to produce new measurements, hypotheses, and data sets describing those behaviors. The motivation is to propose theories that explain and predict how illicit teams—such as groups involved in terrorism, smuggling, and other criminal or politically subversive activities—move and communicate. This effort may also lead to knowledge about how licit teams behave, and it may contribute to the development of generalizable theory useful in understanding the behaviors of many different kinds of teams in numerous domains. The project will strive to answer questions such as:

- How do teams move as a unit?
- How do individuals within teams move? Who are the leaders?

- How does communication influence the movement?
- Does movement depend on the goal (e.g., pursuers move differently than hiders)?
- Do communications also depend on goal type?
- What indicators of team processes (e.g., information-gathering, goal-setting, execution) can be revealed by analysis of movement and communications information?
- How do spatial factors, such as boundaries and terrain, influence team behavior and competitive outcomes?
- How do social and cultural factors, such as familiarity (interpersonal, task, environment) and diurnal population flows, influence team behavior and competitive outcomes?

Research Approach

The approach applies statistics, methods, and theories from among multiple disciplines including geography, industrial and organizational psychology, network science, operations research, and strategic studies. The research design uses mixed methods and human subjects; it is an experimental analysis of behavior that uses computer simulation, table-top simulation, and a smartphone-based data collection system to study how small teams pursue goals in both virtual (i.e., laboratory) and real-world environments. This project collects data about the locations, times, message traffic, motivations, decisions, and team affiliations of each player subject. Participating subjects comprise a convenience sample from among an undergraduate student body on a large university campus. Subjects interact as teams in simple games like hide-and-seek. Each team receives objectives (e.g., pursue or evade) and a motive for which to achieve their objective (e.g., winning the game).



Potential Army/Military Applications

Development of knowledge about the geographic patterns of team and multi-team behaviors will support further basic research about topics including team performance, cohesion, resilience, communication, motivation, leadership, and culture. This project may also eventually support applied research in societal instability, criminology, radicalism, management science, and computer simulations. Applied research in these interest areas may in turn lead to engineering and development that would be meaningful to many professional communities. It is hoped that such advances will ultimately lead to improvements in civil services, social welfare, and public safety at home and abroad.

Some examples of potential applied research topics and questions that might be of interest to the U.S. military may include:

- *Targeting and Decision Support in Irregular Warfare:* What patterns of movement and communication may permit identification of hidden discrete teams operating within large populations? How can understanding the geographic dynamics of goal-directed social behaviors assist in differentiating illicit social networks operating clandestinely to achieve politically subversive goals?
- *Migration, Border Enforcement, and Trans-Border Communication:* What factors influence how teams move, communicate, and make decisions in different geographies? How do these factors change in different cultures, under different hierarchical constructs, or with different communications technologies?
- *Cohesion and Culture:* How do teams and systems of teams behave in ways that improve cohesion, relational bonds, and goal accomplishment? How do changes in organizational culture correlate with changes

in the operational activities of front line teams? When and how do outwardly observable behaviors indicate serious dissension within teams?

- *Disaster Response and Recovery:* How do survivors move and communicate as teams in the aftermath of natural and man-made disasters? What team behaviors correlate with successful disaster response and recovery operations such as urban search and rescue? How do disaster response team members learn about their environment and communicate with each other?
- *Support to Civil Authorities:* What variables may indicate the time, location, and severity of mob behaviors such as rioting, looting, vandalism, and other unlawful “flash mobs?” What variables suggest when and where these behaviors are likely to metastasize, relocate, or subside?
- *Military Information Support Operations:* How do discrete influence networks propagate memes in geographic space? What indicators suggest how, when, and where economic, cultural, and political “tipping points” occur?
- *Post-Conflict Stabilization, Economics, and Society:* How do teams (or quasi-teams) associate, move, and communicate to maximize revenue in industries characterized by mobility and cooperative competition (e.g., street vendors, fisheries, taxicabs, etc.)?

Future Plans

Over the next year, this project will proceed along five primary lines of activity: statistical development, table-top exercises, pilot full-scale exercises, live full-scale exercises, and post-processing and analysis.

- *Statistical Development:* This activity involves studying expected values of statistical measures of goal-directed social behaviors in a series of developmental case studies. This

activity also includes developing the smartphone software, integrating that software with sensor hardware and networks, and developing a customized statistical analysis application.

- *Table-Top Exercises:* After human subjects research approval and informed consent have been obtained, participants will engage in table-top exercises to begin producing empirical observations. Exercise preparation involves recruiting participants, collecting materials, making logistical arrangements, and configuring the laboratory instrumentation (see Figure 1).
- *Pilot Full-Scale Exercises:* Several pilot studies will help implement a full-scale data collection system in real geographic space, assess data quality, evaluate statistical outputs, and troubleshoot (see Figure 2). This activity involves configuring and testing systems as well as implementing remediation.
- *Live Full-Scale Exercises:* A major portion of this activity is dedicated to recruiting, screening, and obtaining the informed consent of participating subjects. The researchers will form teams of individuals and allow the teams to become familiar with each other and discuss their tasks. Players will engage in the exercise, move about the study area, and communicate via various media. The researchers will monitor the quality of data collected and direct any maintenance needs. Afterwards, the researchers will interview the participants in group and/or individual settings.
- *Post-Processing and Analysis:* Processing includes cleaning, loading, and examination to prevent any corruption that might disrupt analysis. Analysis includes generating statistics, making comparisons, and investigating interesting correlations. The researchers will form hypotheses to explain these observations and begin investigating these hypotheses. This activity also includes preparing reports to summarize these findings and conclusions.

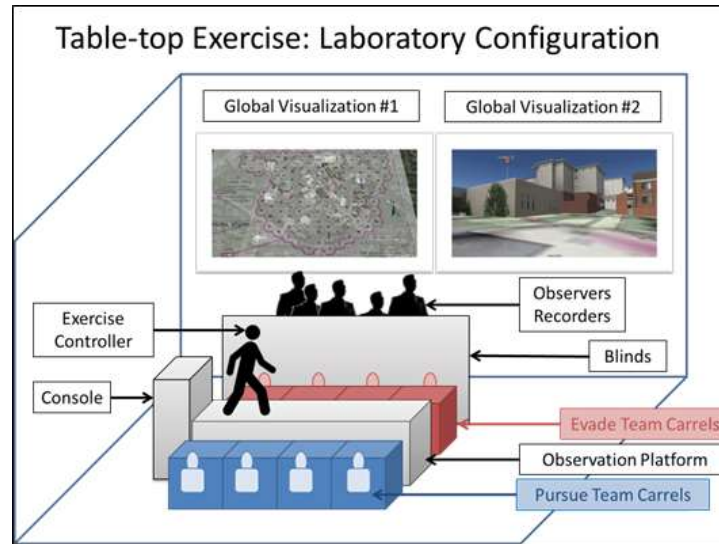


Figure 1. Table top exercise: laboratory configuration. Participant subjects will engage in table-top exercises in a virtual visualization laboratory that maintains player perceptions separately from the global representation of player-to-player, player-to-team, and team-to-team interactions.

Smartphone-based Reality Mining for Geographic Dynamics of Goal-Directed Social Behaviors

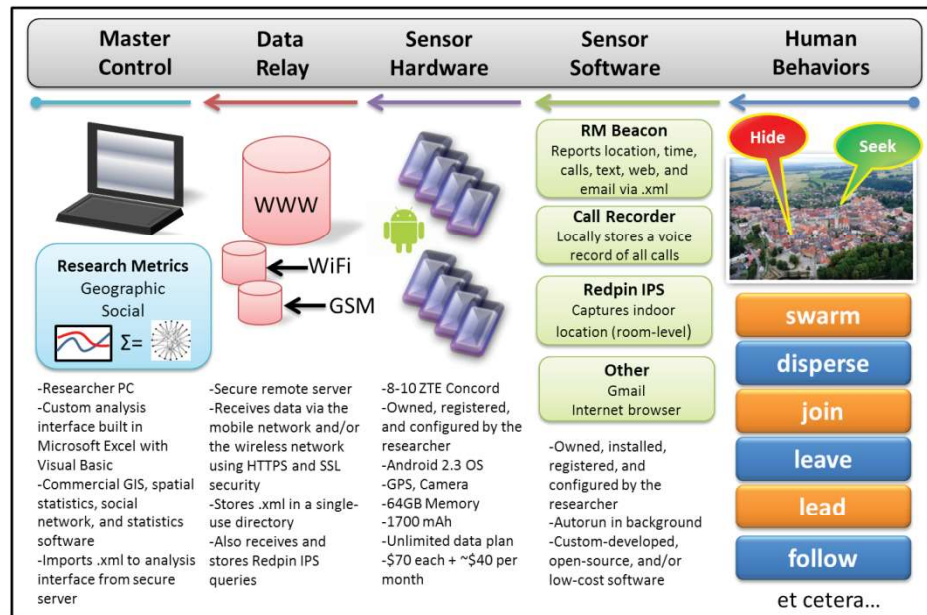


Figure 2. An integrated information system will collect data about the real-world movements and communications of participant subjects engaged in the full-scale pursuit-and-evasion exercises.



A Computational Modeling Approach to Organizational Effectiveness: Mapping the Effects of Leadership, Group Structure, and Environmental Shocks

Contract #: W911NF-14-1-0026

Contract Dates: 16 MAY 2014—15 MAY 2019

PI: Steven Kozlowski

Institution: Michigan State University

Co-PI/Subcontractors: Georgia T. Chao; Michael T. Braun; James A. Grand

Among the major problems in organizational research is the challenge of getting a wide range of variability on core constructs and the challenge of capturing the dynamics of core process mechanisms across multiple levels of analysis. The vast majority of organizational research is based on limited sampling strategies (i.e., single organizational samples) that constrain variance and static research designs (i.e., cross-sectional data) which fail to capture processes directly. This research uses computational modeling to conduct virtual simulations that will enable full exploration of a meaningful theoretical space relevant to the focal phenomena. Implications focus on advancing a dynamic, multi-level representation of multiteam systems that can be used to identify critical leverage points for personnel practices and future empirical research aimed at improving organizational effectiveness.

The ability to foster and maintain agile teams is a core competency for the U.S. Army. Three aspects of team adaptability are particularly critical: (a) how individuals and teams with diverse attributes and backgrounds can work together effectively; (b) how leaders can align individual behaviors to enhance team and multiteam system outcomes; and (c) how the capacity of teams can absorb internal and external shocks (e.g., changes in group composition, tasks, member interdependencies, environmental shifts) and successfully adapt their processes to meet unforeseen changes. This research maps how teamwork emerges—bottom-up—to shape team, multiteam system, and organizational effectiveness. The first phase of work will focus on the team level (i.e., process mechanisms within teams). We will examine the mechanisms by which leaders' relative emphasis on formal versus informal team structures shapes different patterns of team collaboration. The research will develop a set of principles that address when and

how these structures can be coordinated to facilitate team performance and how team composition should be aligned to facilitate team effectiveness. The second phase of work will extend Phase 1 to focus on multiteam leadership structures and multiteam composition features (i.e., process mechanisms between teams). The third phase of work will examine how formal and informal group structures should change in response to an environmental shock that fundamentally modifies the mission and/or composition of the group. Patterns of change and adaptation that emerge from environmental shocks are likely to depend on social or cultural identities that tie two individuals or groups together. Leadership styles and behaviors can be instrumental in helping a group adjust. Figure 1 describes how these components for team dynamics can interact to influence team, multiteam system, and organizational effectiveness.

Although organizational science has many narrative theories that speculate on the complexities of within and between

team interaction processes, such theories lack precision and are difficult to apply to real world problems. Computational modeling (CM) is a research approach based on the specification of formal theory, development of precise process mechanisms, and use of virtual experimentation. This combination of research tools is capable of developing fundamental principles of team and multiteam system effectiveness. The CM, coupled with agent-based simulation (ABS), maps relevant theoretical spaces, can explore “what if” scenarios, and provides a basis for specific application-relevant recommendations. This approach will enable the researcher to explicitly control features of leadership, team composition, and environmental shocks; to systematically identify principles relevant to forecasting team and organizational outcomes.

Research Approach

This project will develop a theoretically-based CM to understand how leadership, formal and informal structures for team member interactions, team composition, and internal and external shocks shape the nature of unit collaboration, adaptability, and effectiveness. A CM provides a mathematical depiction of a phenomenon of interest representing the mechanisms by which a dynamic process unfolds. It is focused on the fundamental mechanisms of emergence as a “bottom-up” process. Such models specify mathematical equations or logical if-then statements to describe system dynamics from one time point to the next. Thus, the computational model formally specifies a set of rules or goals that guide the behavior of entities or “agents” of interest, in dynamic interaction with other entities. The CM is instantiated in an ABS, such that multiple entities—each with their own unique properties—will be used to represent interacting micro-level units nested within teams and a broader multiteam system.



team collaboration and team outcomes such as cohesiveness and performance. Currently, we are designing the task architecture for a CM. The task structure is critical for specifying basic work process mechanisms whereby the actions of team member agents are linked together. Task structure design includes specifying the overall task and specific subtasks, individual attributes of agents (team members), timing of team process dynamics, and rules for agent-task interaction, as well as defining pathways for leader and agent influence.

Research plans for the remainder of this first year include development of the computational model and conducting virtual experiments to evaluate basic propositions on the influence of leadership and team composition on team processes and outcomes.



The Development and Construct Validation of Unobtrusive Dynamic Measures of Team Processes and Emergent States

Contract #: W911NF-15-1-0014

Contract Dates: 22 DEC 2014—21 DEC 2019

PI: Scott Tannenbaum, Group for Organizational Effectiveness, Inc.

Co-PI/Subcontractors: John Mathieu, University of Connecticut

This research is geared towards the development of new methods for classifying, measuring, and using complex data from teams and groups to understand group processes. This project will help develop new methods to aid in the linguistic analysis of teams and groups and identify methods that may be used for effective unobtrusive measurement—that is, gathering useful data about groups without intrusive surveys and assessments.

The inability to easily employ dynamic construct-valid leading indicators of team effectiveness is an Achilles heel limiting the developing and testing of dynamic models of team performance. ARI is interested in measurement approaches that avoid the use of traditional surveys completed by team members or observational ratings by subject matter experts. We propose a theoretical framework, measurement protocol, and methodology to better understand and predict team behavioral processes and states in dynamic social networks using unobtrusive measures.

Whereas recent theory and practice have emphasized the importance of viewing team effectiveness in dynamic temporal frameworks, traditional methodologies limit assessments of processes and states to relatively few occasions, and typically rely on costly, subjective, and intrusive data collection methods (e.g., self-report ratings and surveys or time-consuming observational coding of behaviors by researchers).

The proposed program of research is designed to overcome these limitations and to develop dynamic measures of team processes and states based on communication patterns and other information that

can be gathered unobtrusively, indexed automatically, and analyzed using longitudinal methods.

If successful, this program of research will facilitate the advancement of team effectiveness theory, research, and practice by enabling the detailed examination of dynamic relationships in a manner that has not previously been feasible.

We propose a methodology to convert team member communications, via computer-aided text analysis (CATA), into indices of team processes and emergent states. We further propose to index team dynamics in terms of network configuration and to model their relationships with team outcomes in dynamic environments.

Research Approach

In Year 1, we establish the guiding framework and develop generic team process and emergent state dictionaries to apply to existing data sets of team communications, yielding indices of key team dynamics and cross-validate these against traditional measures.

During Year 2, we will extend the generic solution to focus on specific types

of teams, develop targeted supplemental dictionaries, and index team dynamics over time using unobtrusive measures.

In Year 3, we will collect team communication data in concert with sociometric information (using unobtrusive badges) and will synthesize those data streams into a more comprehensive assessment of team processes and states.

In sum, the proposed line of research is designed to provide a workable methodology for unobtrusively capturing, indexing, and modeling dynamic team processes and states that can serve as leading indicators of team effectiveness and to address a key obstacle to the advancement of team effectiveness theory, research, and practice.

Accomplishments

In Year 1, we established an **overarching and guiding team dynamics framework**, as well as the particular **dimensions** to be focused upon. This framework will guide the development of various unobtrusive diagnostic tools aligned with the state of the art in team scholarship. A preliminary version of this framework was submitted for consideration in the yearly review issue for the Journal of Management and received an invitation to submit a complete version—that is, a revise and resubmit. In brief, as illustrated in Figure 1, the framework advances the idea that achieving measurement fit for dynamic team constructs involves clear explication of the construct space and then aligning both measurement features and contextual considerations.

We have begun initial **developmental work for establishing generic dictionaries** (for use with Diction and other software) to index different team dynamics. These dictionaries are in the process of being refined using existing databases of team communications. One set of dictionaries has been developed to index a taxonomy of **team processes**

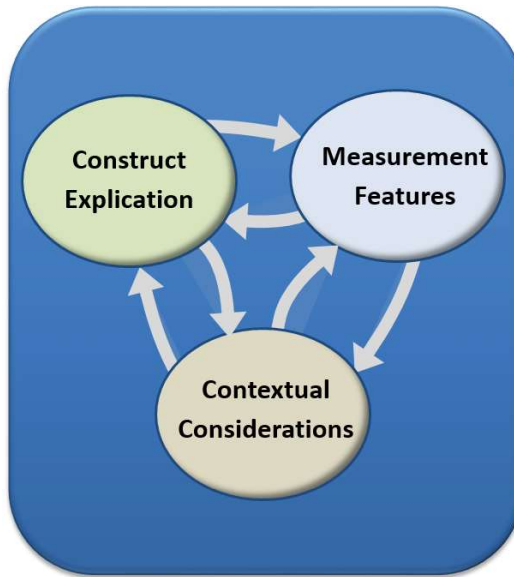


Figure 1. Team dynamics framework to guide measurement.

(Marks et al., 2001) both in terms of relatively narrow first-order constructs (e.g., goal specification, affect management), as well as the three corresponding higher-order constructs (i.e., transition, action, and interpersonal processes). In a second initiative, we have developed dictionaries for indexing **team resilience** at different levels of specificity. In addition, we have begun developing customized supplements for different task environments for preliminary “proof of concept” and validation efforts.

We have partnered with APTIMA/ARL (Army Research Laboratory) and begun the process of gaining access to data from MCTP (Mission Control Training Program) exercises. This will include two qualitative investigations (led by Colonel Dale Watson), and a full scale data collection. This has evolved into an on-going collaboration with APTIMA (Dr. Kara Orvis and colleagues) and ARL (Dr. Arwen Decostanza and colleagues). MCTP may well serve as a prime venue for data collection throughout the duration of the grant. We are also discussing with APTIMA/ARL the potential use of existing MCTP data in initial validation

work, and we have submitted the appropriate IRB materials to gain such access. This environment has the added benefit of being a multi-team system, allowing us to examine unobtrusive team measures within and between teams in a complex, military simulation.

Contributions to Basic Research

A major limitation in research on team dynamics is an over-reliance on self-report survey measures. While surveys are a useful research tool, they are subject to self-report bias and in some cases, individuals “are not aware of what they don’t know,” so simply asking them for their perspective may not yield accurate insights. Moreover, survey administration is simply not feasible in some research environments.

Finally, there is a concern with survey fatigue, which can occur when individuals are asked to complete surveys too frequently. Therefore, there is a need to supplement the existing research toolkit

with new and innovative ways of examining team dynamics that do not rely on self-report measures.

This program of research targets that basic research need, starting with the establishment of an organizing framework for thinking about dynamic unobtrusive measures, and moving forward with the development and testing of specific unobtrusive measures, based on, for example, naturally occurring communication patterns and physical proximity of team members.

This research will help establish the boundaries of what is feasible, provide a launching point for future research efforts, and, we hope, yield a few innovative methods for gathering and analyzing unobtrusive indicators of team dynamics. The framework and methods produced during this effort should have a significant effect on basic research on team effectiveness.

Potential Army/Military Applications

The Army and other branches of the military rely heavily on teams to accomplish their mission. Teams are complex entities, and this program of research can help the Army mission in two fundamental ways. Most directly, it will address a key obstacle to conducting the next generation of team effectiveness research. Should the proposed approach prove valid, it will allow the Army to conduct better, more targeted research on team effectiveness.

Secondly, the methodological approach and techniques we will be developing through this program of research could serve as the foundation for the establishment of future diagnostic tools to assess team dynamics and emergent states dynamically and unobtrusively. Such tools could be used to maintain awareness of team readiness and risks, highlighting when intervention may be needed by



leaders and commanders. Next-generation unobtrusive team measurement tools could also be used to improve the efficacy of team training efforts; for example, by providing enhanced information to instructors or guiding more targeted after-action reviews.

Future Plans

During Years 2 and 3, we will extend the generic solution to focus on specific types of teams. We will develop targeted supplemental dictionaries that can be combined with the generic ones for use in specific settings. Using unobtrusively gathered data, we will then index team dynamics over time, in a network framework.

In so doing, the research will advance from teamwork in general to teamwork in context, and from tracking team interactions as an undifferentiated whole, to a more detailed analysis of interactions among members. Our analyses can also examine how well different media (e.g., face-to-face, radio communications, IM) convey different types of information about team dynamics.

We will collect team communication data in concert with sociometric information (e.g., members' physical proximity, communication turn taking) gathered through an unobtrusive badge and will synthesize those data streams into a more comprehensive assessment of team processes and states. We will develop and validate a methodology for integrating communication analyses with sociometric information, illustrate dynamic multiplex network analysis techniques and applications, and identify key temporal trends in the evolution of team processes and state outcome relationships.





SOCIO-CULTURAL CAPABILITIES

DR. STEFANIE A. PLEMMONS, 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:
defining and refining the meaning of culture, understanding cultural differences in teams and groups, and 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 improve 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

ARI's Basic Research Program strives to develop improved methods for assessing culture that integrate methods from psychology, sociology, ethnography, and anthropology. These methods may include or address concepts such as situational strength, cultural memes, and 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. STEFANIE A. PLEMMONS, RESEARCH PORTFOLIO LEAD

Currently Funded Research

ARI's Basic Research Program is currently funding two extramural research projects.

Brief descriptions of the contracts are provided below, with detailed research summaries of each contract provided on pages 65-69.

The Role of Implicit and Explicit Cognition in Cultural Learning

(W911NF-13-1-0113; 2013–2017)

Dr. Michael Morris's (Columbia University) 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.

The Etiology and Consequences of Organizational Conflict Culture

(W911NF-15-1-0011; 2014–2018)

Dr. Michele Gelfand's (University of Maryland) research examines a comprehensive model of conflict culture, including such precursors as leadership, team composition, and situational constraints, and such outcomes as team efficiency and effectiveness. The research addresses several specific research questions involving organizational culture processes, including research questions related to the interplay of leadership, organizational structure, and team composition on unit culture.



The Role of Implicit and Explicit Cognition in Cultural Learning

Contract #: W911NF-13-1-0113
PI: Michael W. Morris

Contract Dates: 15 AUG 2013-14—14 AUG 2017
Institution: Columbia University

Cultural competence is a critical skill for service members deployed overseas. As such, better selection and training of intercultural understanding would prove highly beneficial to the military. The current set of studies develops and tests a model of implicit cultural learning from interpersonal situations, asserting that cultural competence hinges largely on awareness of situation-behavior-outcome contingencies that people learn from social situations. It is expected that individuals with better implicit learning ability and multi-cultural backgrounds will exhibit steeper learning curves of cultural competence. The project moves past models of explicit learning and examines the interplay of implicit and explicit learning on the cultural learning process.

Intercultural learning is crucial to the effectiveness of defense missions. The current research draws on recent developments in the fields of cognitive and cultural psychology to propose a model of cultural learning from everyday interpersonal interactions. In the process, we develop new methods for training and selecting individuals for intercultural adaptability. Our proposed studies build on recent preliminary work on the role of situations in cultural conditioning of decision-making. We will test the relative contributions of individuals' explicit and implicit learning abilities, explicit and implicit cognition, and metacognitive propensity, in shaping individuals' success at cultural learning.

To illustrate experiential and vicarious learning of a new culture, let us start with the example of Rex and Jose, recently arrived U.S. military personnel in the Helmand Province of Afghanistan. Rex studied political science in college and is working his way through a stack of books on Afghan history. With a pre-deployment semester of Pashto, he can read and write simple sentences. Yet since the local dialect is different from that he learned in class, Rex struggles to comprehend conversations or express

himself to the locals. Also, while Rex has studied ethnographies of Pashtun customs and can describe them articulately, he is perplexed to observe that the younger generation of Afghan soldiers does not adhere to all these customs. Jose arrived with little pre-deployment training but lots of curiosity. Rather than learning from a classroom, he learns best by meeting people—drinking tea, sharing meals, and visiting shops. An outgoing person with a good ear, he quickly picked up phrases for greeting different kinds of people in different situations, though he uses some phrases without knowing exactly what they mean. He has made friends and feels he is “getting the hang of it” in terms of working effectively with Afghan people, yet he is not adept at explaining what works to others.

While Rex and Jose are both learning about Afghan culture, they go about this in very different ways: Rex more academically and Jose more intuitively. These examples represent the two extremes of learning based upon two distinct mental systems. As we should see, learning from experience often involves combinations of explicit and implicit cognition. The current project seeks to explore this phenomenon.

Research Approach

In our experimental procedure, participant-trainees will be presented with depictions of interpersonal interactions in a foreign culture. For example, in some studies, participants will be shown pictures of individuals from the other culture and asked to select the greeting that they would engage in (for example, bowing versus shaking hands). In other studies, participants would be presented with descriptions of interpersonal influence situations and asked whether they would accommodate to the influencer or not. Participants would receive feedback based on whether the chosen action is culturally appropriate or not. After this training phase, participants' explicit understanding of the appropriateness of various actions in a new culture would be assessed. We would both measure and manipulate explicit and implicit processing, and the propensity to engage in metacognitive thought, to test their respective roles in cultural learning. Our model suggests novel ways of selecting and training individuals for foreign culture assignments.

Contributions to Basic Research

Learning and Training: Techniques to elicit knowledge from experts and alternate sources.

The armed forces typically elicit knowledge from subject matter experts, such as academic experts, practitioners, and previously engaged armed forces personnel. However, local people also have a wealth of cultural knowledge that can be tapped. Whereas behavioral scientists have used experience sampling techniques to elicit people's thoughts, feelings, and behaviors, the present research uses the related situation sampling technique for a novel purpose: to elicit information about everyday situations from people who experienced those situations. If successful,



the situation sampling technique might be an additional resource for researchers to collect information that would be useful in a variety of settings and applications.

Personnel Selection and Assignment

The proposed method attempts to link implicit and explicit processing capacities, as yet unstudied in the domain of cultural learning, as key individual difference variables that predict individuals' ability to implicitly pick up patterns occurring in everyday interpersonal situations. If successful, both individuals' general processing capacities (as assessed through standard cognitive tasks) and more specific aptitudes (as measured through sub-scales of the cultural intelligence scale) can be used to select individuals who would be best suited for tasks that involve close interaction and collaboration with locals, such as atmospheric teams.

Potential Army/Military Applications

Learning and Training: Methods designed to structure poorly specified knowledge.

Everyday situations contain a wealth of information about how individual actors respond to events; about people's thoughts, feelings, and behaviors in everyday life; about the social roles of different individuals in different circumstances; about the prevalent norms of behavior in different circumstances; and about which thoughts, feelings, and behaviors are appropriate in the culture and which are not. However, this information is poorly specified and difficult to capture. Whereas armed forces personnel are given extensive training about customs, norms, and behaviors common in the host culture, they are usually not provided information about the types of mundane situations they are likely to encounter routinely in the host culture and how to act appropriately in

those situations. The proposed research attempts to capture unstructured information contained in everyday situations by collecting verbal descriptions of situations and the behaviors that were appropriate or inappropriate in those situations. In the future, researchers can collect samples of situational expectancies from societies where Army personnel are going to be involved and expose the personnel to a large collection of such situations to familiarize them with the atmospherics of the host setting.

Learning and Training: Methods for increasing the basic level of effective adaptability.

The proposed research aims to develop a method to increase individuals' basic level of adaptability in a new culture by teaching them how to act appropriately in inter-cultural interactions in their new area of operations. The proposed training method is successful and can be implemented with armed forces personnel who might be deployed to a new country, especially those who are likely to extensively engage with the local population. Although time availability is severely restricted in pre-deployment training, the proposed method can be implemented within an hour. The proposed method can also be used in general professional military education to train candidates about cultures where the armed forces are presently engaged in, and therefore, where candidates might subsequently be posted.

Future Plans

We plan to conduct a series of experiments to test the central thesis of this project in the upcoming year. Study 1 will test whether participants' implicit learning ability and their cultural metacognition predict their ability to vary their decisions across situations from different cultures. Study 2 will test whether American participants' implicit learning ability, explicit learning ability, and cultural metacognition

predicts their ability to learn to make systematically different decisions in situations derived from India. Study 3 will test whether Indian participants' implicit learning ability, explicit learning ability, and cultural metacognition predict their ability to learn to make systematically different decisions in situations derived from the U.S. culture. Studies 4 and 5 will test whether Singaporean participants' implicit learning ability, explicit learning ability, and cultural metacognition predict their ability to learn to make systematically different decisions in situations derived from the U.S. and India.

These five studies will further test the predictive ability of multiple measures of implicit learning ability, such as the artificial grammar learning task and the probabilistic classification task, along with contrast implicit learning ability with comparable measures of explicit learning ability and IQ. To provide experimental support for the findings, Study 6 will test whether disrupting people's ability to learn through implicit processes using a delayed feedback manipulation will make it more difficult for them to learn to alter their decision making in situations from another culture. The findings, if consistent with the hypotheses, would highlight that cultural adjustment is not simply a matter of acquiring explicit knowledge but of learning complex patterns implicitly. We will also test whether participants can verbalize the probabilistic rules of behavior that they have learned in the situation simulation task.



The Etiology and Consequences of Organizational Conflict Cultures

Contract #: W911NF-15-1-0011
PI: Michele J. Gelfand

Contract Dates: 15 DEC 2014—14 DEC 2018
Institution: University of Maryland, College Park

The current project investigates from a multilevel perspective the top-down and bottom-up influences on conflict cultures within organizations. A series of studies, including qualitative interviews, surveys, and ethnographic observations, will be conducted to examine the determinants and outcomes associated with four distinct conflict cultures: dominating, collaborative, avoidant, and passive-aggressive. Identification of multilevel determinants and outcomes is expected to assist in the diagnosis and modification of conflict culture based on unit composition and tasks. The current project also has implications for personnel assignment, as a knowledge of individual differences and unit conflict culture may assist in improving fit within a unit.

Conflict is an inherent part of organizational life and has profound implications for outcomes at the individual, unit, and organizational levels. While ample research has explored individual factors that impact conflict within organizations, particularly individual conflict management styles, we suggest that there are key factors at the unit and organizational level that shape how conflict is managed in organizations. Though individuals may have idiosyncratic preferences for different conflict management strategies, we argue that organizational contexts provide strong situations that serve to create shared and normative ways to manage conflict—what we have referred to as distinct *conflict cultures*. These conflict cultures ultimately minimize individual variation in conflict management strategies in organizations. Initial explorations of organizational conflict cultures suggest that these cultures vary along two primary dimensions: (a) active versus passive conflict management norms and (b) agreeable versus disagreeable conflict management norms. These dimensions produce four distinct conflict cultures: *dominating* (active and disagreeable),

collaborative (active and agreeable), *avoidant* (passive and agreeable), and *passive-aggressive* (passive and disagreeable). These conflict cultures arise from unique constellations of variables, including top-down and bottom-up factors within units.

The present research will provide a systematic investigation of the factors shaping conflict cultures in a multi-site hospital system and their consequences at the individual, unit, and organization level. We will assess top-down affordances of conflict cultures, including unit leader personalities, leadership behaviors, unit organizational structure, reward structures, and situational factors, such as threat and time pressure. We will also explore bottom-up forces, including personality, values, and demographic composition of the work units. Using archival, survey, and observational data, we will illuminate the multilevel outcomes associated with conflict cultures, including incivility, harassment, unit viability, turnover and absenteeism, and satisfaction. We will also examine bottom-line outcomes, such as patient errors, length of stay, readmission rates, number and

type of patient complaints, patient death, patient satisfaction, and lawsuits, among other variables that are available.

Research Approach

This research will be guided by a multi-method research approach that involves interviews, survey research, observations, and archival data collection. Qualitative interviews of hospital staff in multiple units will inform, expand, and refine our culture conflict theory. A large-scale survey effort will assess conflict cultures, their top-down and bottom-up sources, and their consequences amongst individuals, including physicians, nurses, staff, licensed practitioners, and support personnel across more than 200 units. This survey will be integrated with archival data on bottom-line outcomes. Based on the results of the survey, we will select units that reflect the prototypes of our different conflict cultures and conduct ethnographic observations to provide additional validation evidence for the quantitative data and illuminate additional dynamics that expand the theory. The primary data-analytic approaches used will be content analysis of the qualitative data, exploratory and confirmatory factor analysis, multiple regression, and random coefficient modeling.

Accomplishments

In the first 4 months of the grant administration, we have coordinated with key contacts within the hospital system to lay the groundwork for the project. Kick-off meetings with these contacts and stakeholders provided briefings on the structure of the hospital system, as well as the history of conflict, conflict cultures, and professionalism at the institution. We also discussed previous and ongoing efforts to assess professionalism and conflict cultures in the system, as well as the current safety monitoring questionnaires used in the hospital. Finally, we developed a joint



action plan and coordinated a timeline for meeting project milestones.

We have also initiated key efforts aimed at refining and extending the initial framework of the etiology and consequences of organizational conflict cultures. We began several literature searches and reviews designed to provide a thorough foundation for future activities. First, we conducted a general review of medical systems, hospital reporting structures, and medical education to provide background information on potential institutional and industry factors that may impact conflict cultures. Second, we reviewed previous organizational research conducted within hospital and medical settings to determine key predictors and outcomes studied within these settings, with an eye toward creating a comprehensive list of relevant metrics and measures for later survey development. Third, we searched the organizational psychology, medical, and medical education literatures for topics related to organizational conflict cultures, including but not limited to civility, professionalism, and the “dark side” of organizational behavior (e.g., passive-aggressiveness, incivility, harassment, bullying, etc.). Finally, we conducted a literature search on cultural memes to inform our theories on the development and propagation of conflict cultures.

Contributions to Basic Research

This research has the potential to make significant advances in the science of conflict and organizational culture. A shift to studying conflict management at the organizational level is critical for advancing theory, research, metrics, and practice and complements extant research by adding a higher level of analysis—the organizational level—to study of conflict in organizations. Despite considerable progress in the study of conflict management at the individual and small group level, there has been a critical gap in studying higher levels

of analysis; with few exceptions, there has been very little theory and research on how conflict management operates at the *macro*, organizational level. Put differently, while conflict is often argued to be part of organizational systems, the literature on conflict is paradoxically largely divorced from any organizational context. The current project will fill this lacuna by examining how specific aspects of the organizational context, namely the conflict culture, impacts conflict management throughout organizations and within units.

Moreover, a conflict culture perspective integrates conflict research directly into the mainstream of organizational sciences literature. By taking an organizational-level perspective on conflict, conflict management literature becomes intricately related to core topics such as leadership, structure, culture, organizational change, issues of attraction-selection-attrition and person-organization fit. Accordingly, understanding how conflict cultures are created and sustained through top-down and bottom-up processes, and how they are linked to organizational-level outcomes, will help to integrate the conflict management field with other core organizational behavior topics.

This project will also contribute to advancements in the measurement of conflict at the organizational level, as well as its predictors and consequences. Prior to the current project, a proof of concept study using a new measurement showed that conflict cultures do, in fact, exist within organizations and operate at the unit level of analysis (Gelfand et al., 2012). This study showed distinct conflict cultures in different branches of a bank and that perceptions of the conflict cultures were shared amongst branch members. Further, this study showed that the different conflict cultures were related to key predictors and outcomes, including leadership, psychological safety, burn-out, unit cohesion, and customer service. While providing some support for an organizational conflict culture perspec-

tive, this study was limited in its scope, which the current project will remedy. Through our collaboration with the multi-site medical system, we will be able to collect data from numerous sources to test the measurement of conflict cultures as well as their multilevel predictors and consequences.

Potential Army/Military Applications

As conflict is an inevitable part of organizational systems, it needs to be examined and managed from a macro cultural perspective. Our systematic research on organizational conflict cultures will provide evidence-based research that will enhance the operations of the United States Army through its impact on (a) identification, (b) modification, and (c) alignment of conflict cultures. Through this research, the Army will be able to *identify* a coherent picture of the particular key features of each of the four conflict culture types, allowing Army leaders and command to diagnose the conflict cultures present in particular units or parts of the organization. This is necessary for the second element: *modification*. By having the ability to diagnose the type of conflict culture in place and by also understanding the causes that create and sustain particular conflict cultures, practical interventions can be developed to modify them to a more desired type. Finally, *alignment* concerns the relevant outcomes attached to each conflict culture and how they match the particular goals of a unit in question.

This project may also impact a number of additional factors and processes that support and enhance Army capabilities. Information gleaned from this project on person-organization fit may enhance selection and placement processes within the Army. Individuals with certain personality types or personal values may be better suited to working within one conflict culture over another. For example, a very extroverted and disagreeable



Soldier may fit better in a dominating or collaborative conflict culture, given the active conflict norms of these systems over more passive cultures. Enhancing person-organization fit vis-à-vis organizational conflict cultures can have a number of important consequences at the individual level—including Soldier satisfaction and commitment, as well as at the unit level, such as unit performance and safety.

Further, this project can help address potential deleterious forces that inhibit effective functioning in the Army. Our multi-level approach to exploring the consequences of conflict cultures will provide key information on the “dark side” of organizations, including counterproductive work behaviors, incivility, bullying, and physical and sexual harassment. Our project will provide systematic, evidence-based information on how conflict cultures may facilitate or inhibit these negative behaviors, as well as crucial insights on potential levers to modify conflict cultures to avoid these destructive processes and outcomes.

This research will also explore how conflict cultures relate to diversity in organizations. Our findings will help inform and support the Army’s diversity mission. First, we will test to see if conflict cultures differentially affect women and racial and ethnic minorities in organizations. For example, dominating or passive aggressive conflict cultures may create a difficult or hostile environment for women and racial and ethnic minorities, given that the norms inherent to these cultures are highly competitive in nature, and/or because they might receive backlash when they engage in competitive styles that are consistent with the norms. We will also investigate the possibility that conflict cultures may moderate the effects of *work unit diversity* for individual and unit-level outcomes. Some conflict culture types are more likely to inhibit the ability for diversity to result in positive outcomes, while others are more likely to unleash the power of diversity for creativity. For example,

dominant conflict cultures may foster stereotypical thinking, distrust, conflict, and a lack of information sharing among diverse group members. Accordingly, diverse groups should have much lower performance than homogenous groups in dominating conflict cultures. This effect may be especially likely for more visible forms of diversity (e.g., age, gender, ethnicity, etc.). In contrast, collaborative conflict cultures may provide the most useful organizational context for the innovative and creative outcomes associated with diversity. As they cultivate an open, trusting environment that seeks pro-social, constructive solutions, it may be the best place for different perspectives to be heard and taken into consideration.

Future Plans

In the upcoming year, we expect to continue refining our existing theory on organizational conflict cultures and to prepare for the upcoming large-scale survey within the hospital system. We will conduct content analysis on the focus group data from the hospital system, with a focus on understanding the common themes and experiences across units as well as unique perspectives within units. Together, the information gleaned from the focus groups and literature searches will be used to develop and refine a list of initial metrics and data collection procedures for the survey. Based on this list, we will begin the survey development process, including creating and/or refining leader and unit scales related to conflict cultures. We will also work with hospital personnel to develop a clear schematic of the hospital structure, which we will use to target work units for survey participation. We will research and test potential platforms for the large-scale survey deployment and work with our collaborators to identify participants to be included in the pilot samples for the survey. We plan to launch at least one pilot wave of the survey, after which we will refine the survey and its deployment method to address any problematic items or features. Finally, we will launch

the large-scale survey and begin data analysis.

Associated Publications

- SIOP 2014 William A. Owens Scholarly Achievement Award, Society for Industrial-Organizational Psychology, best paper published in 2013 (Gelfand et al., Conflict Cultures in Organizations: How leaders shape conflict cultures and their organizational-level consequences, *Journal of Applied Psychology*)
- Gelfand, M., Harrington, J. R., & Leslie, L. (2014). Conflict cultures: A new frontier for conflict management research and practice. In O. B. Ayoko, N. Ashkanasy, & K. A. Jehn (Eds.), *Handbook of Conflict Management*. New York, NY: Edward Publishing, Inc.
- Gelfand, M., Chiu, C.Y., & Hong, Y.Y. (Eds.), in press, 2015. *Advances in Culture and Psychology* (Volume 5). New York, NY: Oxford University Press.





PSYCHOPHYSIOLOGY OF INDIVIDUAL DIFFERENCES

DR. GREGORY A. RUARK, RESEARCH PORTFOLIO LEAD

The formal study of how social, psychological, and behavioral phenomena relate to physiological activity has existed for more than 100 years. Recent advances in measurement technology, to include new measurement tools such as compact sensors resting on the skin surface that non-invasively record internal body functioning and neuroimaging devices to assess brain activity, as well as new and sophisticated statistical approaches, have led to a proliferation of research on the interrelationships of the human mind and body. Examining key areas of significant promise is central to maximizing the usefulness of research from this domain. The great emergence of scientific potential from this discipline has not yet been fully harnessed by the Army, particularly as it relates to understanding and improving the cognitive and behavioral capabilities of the Soldier. 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, the research can advance the understanding of the underlying basis of why people think and behave differently. In the simplest terms, the central focus of this domain is the identification and understanding of what happens or exists inside the brain and body that gives rise to variations between people that lead others to label some individuals as “smart,” “empathetic,” “sociable,” or “extraverted,” among other characteristics.

The overarching goal of this research portfolio is to understand underlying physiological dissimilarities that give rise to observable individual differences in behavior and identify useful biological correlates for psychological constructs with an emphasis on psychological primitives, while advancing understanding of the theoretical framework linking internal body functions to cognitive processes.

Research objectives within this portfolio can be organized into two broad areas:
individual differences and 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 measurable biological and neurological correlates (with an 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.



PSYCHOPHYSIOLOGY OF INDIVIDUAL DIFFERENCES

DR. GREGORY A. RUARK, RESEARCH PORTFOLIO LEAD

Currently Funded Research

ARI's Basic Research Program is currently funding two extramural research projects.

Brief descriptions of the contracts are provided below, with detailed research summaries of each contract provided on pages 73-79.

Optimizing Threat Detection Under Signal-Borne Risk

(W5J9CQ-12-C-0028; 2012–2016)

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; 2012–2016)

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.



Optimizing Threat Detection Under Signal-Borne Risk

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

Contract Dates: 27 SEP 2012—30 APR 2016
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.

How people infer the mood, emotion, or intent of others is called emotion perception. Research has revealed marked variability in people's emotion perception abilities. This variability is a function two factors. One factor is uncertainty and risk in the environment, inherent to perception. Perceivers cannot be certain about what they are seeing; for example, a scowling facial expression can indicate anger or concentration. Furthermore, errors of judgment may be costly; for example, anger and concentration should be responded to differently. A second factor is individual differences internal to perceivers, such as physical and psychological states and traits. This study examines how these factors interact to predict people's emotion perception abilities.

The objective of this research is to characterize individual differences that influence perceivers' abilities to optimally adapt their perceptual decisions to changing levels of environmental uncertainty and risk, in the context of stress. The study focuses on social threat detection (i.e., perception of anger from facial expressions) as a perceptual decision. The objective is implemented via three specific aims. Aim 1 is to identify factors that influence the optimality of social threat detection. We hypothesize

that physiological and psychological factors influence people's ability to make effective perceptual decisions. Some of these factors may be state-like, such as current anxiety or mood. Others may be trait-like, such as physiological response to stress, personality traits, and characteristics of executive function. The goal of Aim 1 is to quantify how high or low "levels" of such individual differences aid or interfere with optimal detection, in environments characterized by 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 detection by influencing the accuracy with which the brain "estimates" three underlying environmental parameters that characterize risk and uncertainty (Figure 1). The goal of Aim 2 is to quantify associations between individual difference factors and ability, or lack thereof, to adapt to changes in the three environmental parameters.

Aim 3 is to use central neurophysiological recordings (electroencephalography, EEG) to identify brain-activity correlates of decision optimization. We hypothesize that specific event related potentials (ERPs) and oscillatory patterns will be

useful neurophysiological markers for different aspects of detection performance. The goal of Aim 3 is to begin linking neural mechanisms of optimal detection with computational mechanisms specified by our model.

Research Approach

Using a utility-based signal detection model of decision making, this study examines how individual perceiver differences contribute to differences in the perception of anger, under conditions of changing environmental uncertainty and risk. We operationalize risk and uncertainty in decision making using signal detection theory's three environmental parameters (Figure 1): perceptual similarity of targets (angry faces) and foils (not-angry face), relative base rate of targets vs. foils, and payoffs accrued for correct and incorrect response to targets and foils. A mathematical model of signal detection uses values of the three parameters to predict how perceivers should categorize the faces in order to maximize net benefits accrued over a series of detection decisions. We also measure a number of individual differences across three domains of psychological function: affective reactivity (physiological response to social stress, induced as part of the study), executive function, and motivation.

Accomplishments

We have completed data collection. Preliminary results indicate that individual differences do affect accurate perception of emotion, as predicted. Important individual differences include, for example, the pattern of one's psychophysiological (e.g., cardiovascular) response to stress, working memory capacity, self-awareness of mistakes, and sensitivity to rewards and punishments.

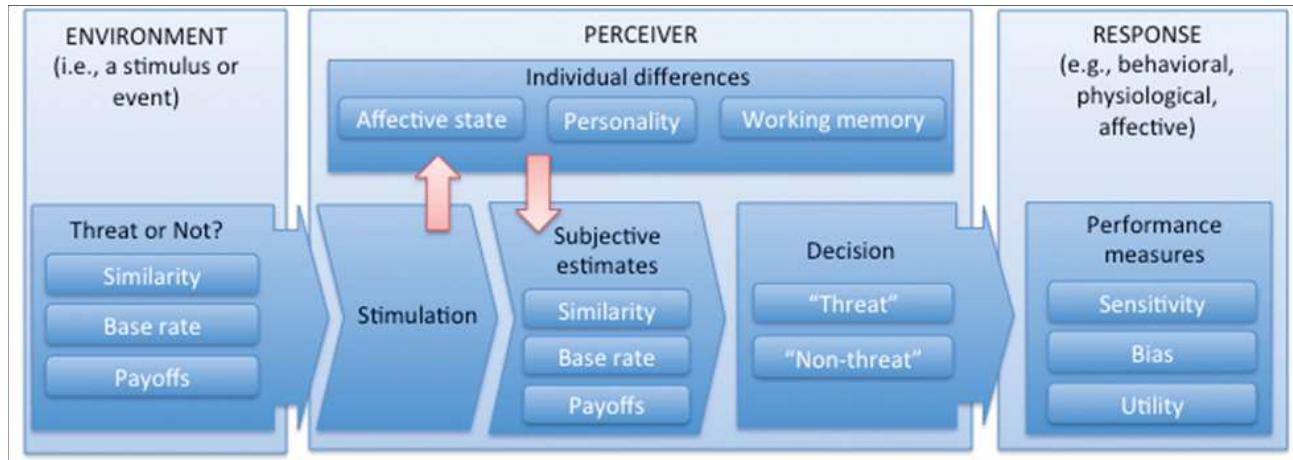


Figure 1. Threats in the world can be described by objective environmental parameters: their perceptual similarity to non-threats, the base rate of occurrence, and the payoffs (benefits and costs) for correctly or incorrectly recognizing them. To effectively recognize threats vs. non-threats, the brain 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.

People whose cardiovascular response indicates that they evaluate our social stress induction (a public speaking task) as a challenge (difficult, but within their capacity to meet) rather than as a threat (difficult, and perhaps too difficult to complete successfully) appear to be better at judging when someone else is angry at them. Likewise, people with higher working memory capacity (a measure of a person's ability to focus on elements important to the task at hand, despite irrelevant distractions), and people with greater self-awareness of their mistakes (in the absence of feedback about correct vs. incorrect behavior) appear to be better at judging when someone is angry than people with lower working memory and self-awareness. These factors appear to be particularly important when perceptual uncertainty is high (when it is difficult to discriminate the cues indicating when someone is angry or not). For example, under high perceptual uncertainty, working memory capacity appears to be an important determinant of a perceiver's ability to adapt his or her decision making to the benefits and costs incurred by correct vs. incorrect detection decisions.

Preliminary results also indicate that a person's sensitivity to rewards and punishment also influences their social threat detection. People who are overly-sensitive to either the benefits of correct response or the costs of incorrect response exhibit worse emotion perception than those who are less sensitive.

Furthermore, in detection tasks in general, including social threat detection, perceivers can commit two kinds of mistakes: false alarm responses and missed detection responses. Our experimental design appears well suited to discriminating sensitivity to these two types of mistakes as an individual difference, and we are excited to develop this line of analysis.

Contributions to Basic Research

This research uses individual difference measures to understand the psychology of effective signal detection. We ask, "What characteristics and abilities make a person good (or

poor) at such a task?" The individual differences we evaluate include physiological, affective, personality and temperament, and cognitive factors. We examine links between these factors and perceivers' abilities to optimally adapt their perception to changing environmental uncertainty and risk. Specifically, we seek to discover associations between individual difference factors and ability, or lack thereof, to adapt to changes in similarity of targets and foils, base rate, and payoffs (the three signal parameters), which operationalize risk and uncertainty in perceptual decision making.

Perceivers' ability to discriminate similar but alternative response options is an important aspect of decision making, measured as perceptual sensitivity. Perceivers' ability to optimize their detection decisions to environmental conditions as well as to their own perceptual sensitivity is an additional important component of effective decision making, measured as response bias. Preliminary analyses indicate that physiological response to stress, working memory capacity, metacognition, reward/punishment sensitivity, and personality traits affect social threat



detection by affecting observed sensitivity and bias measures.

Although we use social threat perception as an example, with its foundation in generalized signal detection theory, our framework is appropriate to any perceptual decision, including those made by non-human agents/reasoning systems. Our approach is intended to produce a foundation for research that can predictively explain, and be used to improve, perceptual decision making. For example, identifying discrete psychological components that contribute to high performance under the operational conditions of our task might enable future applied research to (a) identify personnel well-suited to duties under particular operational conditions, or (b) develop training aimed at improving performance under particular operational conditions.

Potential Army/Military Applications

We will expand fundamental knowledge about how people perceive threat under changing conditions of uncertainty and risk. We seek to discover general principles of perceptual decision making by expanding our current programmatic effort to develop and evaluate key psychological and behavioral theories: signal detection theory and behavioral economics. This research focuses on understanding how internal and external factors interact to influence perception of a non-verbal cue (facial actions), using novel but theoretically well-grounded computational modeling approaches and performance measures. Potential applied future applications of the work therefore include: (a) characterization of the knowledge, skills, and abilities supporting leadership perception and awareness and interpretation of a variety of social cues, (b) development of interventions to enhance understanding of non-verbal cues, (c) development of measures to quantify individual differences in self and social/sit-

uational knowledge and abilities, and (d) development of training and assessment tools and techniques oriented to individual strategies in self and social/situational awareness. Army relevance includes:

- Identifying social perception capabilities that will inform leader development. 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 (e.g., facial expressions) and the risk and uncertainty inherent to perceptual decisions influence a perceiver's judgment about the mental states of others, in light of individual differences in perceiver affective reactivity, executive function, and motivation.
- More broadly, selecting personnel who perform well in particular contexts of decision risk and uncertainty. 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 and motivation, personality, executive function including self-awareness, and appraisal of stress/anxiety) affect people's ability to calibrate perceptions of the environment to appropriate action on those perceptions.
- Identifying decision-making vulnerabilities in individual Soldiers with the aim of providing tailored training. 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 to a source of environmental risk/uncertainty (e.g., poor sensitivity to changing base rates of threat), our approach

may be adapted to enhancing Soldiers' individual perceptual-decision abilities. Our utility-based signal detection model may prove to be an efficient method of performance evaluation, not only in emotion perception, but more generally in any perceptual decision made under uncertainty and risk. Our results may lead to novel training programs, tailored to the skills and experience of the Soldier population being trained or to perceptual decision-making strengths and weaknesses of individual Soldiers, as revealed by our performance evaluation methods.

Additionally, our mathematical model of perceptual decision making and our experimental design are readily generalizable to domains other than mental state attribution due to their foundation in a utility-based signal detection theory. Generalization of our framework to other domains, therefore, offers an additional avenue for future research and application.

Future Plans

As this research continues to show promising results, we can foresee Army relevant follow-on research programs; for example: transition to the Advanced Technology Development Program, creation of an individualized "whole-person" profile of social perception under uncertainty and risk, and tailored training to strengthen "parameter estimation" weaknesses. For example:

- Development of training and assessment tools and techniques oriented to individual strategies in self and social/situational awareness.
- Identification of abilities relevant to Soldier and Officer performance not assessed by the Armed Services Vocational Aptitude Battery and existing standardized cognitive tests—specifically the ability to adapt perceptual decision making to dynamic environments.



Basic research could be extended to domains outside emotion perception and generalization of our framework extended to new domains of decision making, for example:

- Do perceivers who perform well or poorly at this emotion perception task perform similarly on other uncertain, risky decisions?
- Do the same individual differences predict performance in other domains?

Associated Publications

Lynn, S. K., & Barrett, L. F. (2014).

"Utilizing" signal detection theory. *Psychological Science*, 25, 1663–1673.

Lynn, S. K., Ibagón, C., Bui, E., Palitz, S., Simon, N. M., & Barrett, L. F. (2016). Working memory capacity is associated with optimal adaptation of response bias to perceptual sensitivity in emotion perception. *Emotion*, 16, 155-163.

Lynn, S. K.*, Wormwood, J. B.*, Barrett, L. F., & Quigley, K. S. (2015). Decision making from economic and signal detection perspectives: Development of an integrated framework. *Frontiers in Psychology*, Article 952. Retrieved from journal.frontiersin.org/article/910.3389/fpsyg.2015.00952/.
*Shared first-authorship.



Affective Realism: How Feelings Influence Perception

Contract #: W5J9CQ-12-C-0049

PI: Lisa Feldman Barrett

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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 affective 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. Our perception is naturally infused with “affective meaning”—our good and bad gut feelings about the world around us.

The word “affect” comes from the English word meaning “to change” and objects in the world are said to be “positive” or “negative” by virtue of their capacity to shift and influence a person’s gut reactions. We believe something is true about a person or an object in the world because we feel it, and gut feelings are used as evidence for our beliefs, a construct we call “affective realism.”

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?

Soldiers must make quick decisions about other people, whether they are embedded in a unit during wartime, on a peacekeeping mission, negotiating in a cross-cultural setting, or collaborating with unit members on a stateside base. Good leaders must not only harness their own affective reactions as a source of wisdom, but they must also teach their subordinates to do the same. Making a quick judgment of somebody else’s

harmfulness, trustworthiness, or competence in such settings is not a trivial example of person perception. These judgments have consequences for a Soldier’s future mindset and actions, and often for other people’s lives.

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 visual apparatus similar to

one used at the eye doctor’s office called a mirror stereoscope. Using the mirrors, we are able to present a different image to each eye. 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 for a depiction of a trial in the 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 him or her 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).

We also built a battery of tests to measure individual differences in affective reactivity, because we wanted to test whether people who have stronger gut feelings experience stronger affective realism. This

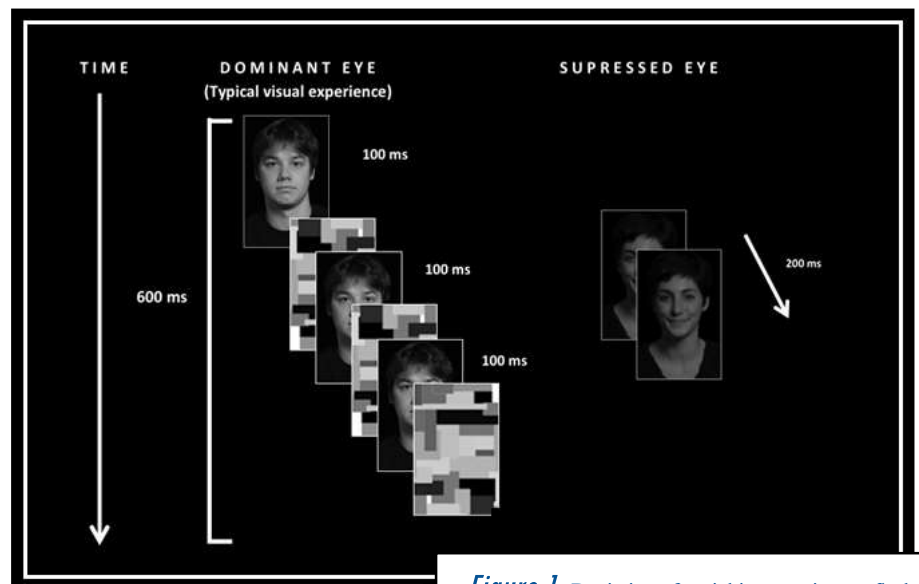


Figure 1. Depiction of a trial in a continuous flash suppression experiment.



battery includes a variety of self-report measurements, plus five different experimental tasks (such as viewing evocative images, performing stressful tasks, and testing sensitivity to bodily changes). All the while, we are recording physical signals from the participant (including information about respiration depth and rate, heartbeats, total peripheral resistance, blood pressure, electrodermal activity, and facial muscle movements that cannot necessarily be seen with the naked eye. The battery takes 3.5 hours to complete, but our goal is to make it more efficient so that it can be used to assess individual differences in affective reactivity in research and applied settings.

Accomplishments

We have conducted nine affective realism experiments and have collected data from 260 individuals in our battery measuring individual differences in affective reactivity (with physiological measurements).

The first six studies were aimed at understanding the mechanisms underlying affective realism. We learned that affective realism changes how people feel (their affect) as well as their heart rate, breathing, sweat gland activity, etc. (i.e., it changes the activation in their autonomic nervous system). We also learned that affective realism actually changes what people see (i.e., their perceptions). And finally, we learned that affective realism occurs in the moment of experience and perception (it does not carry over from moment to moment).

The second set of studies explored how generalizable affective realism is. All of our studies, to date, had demonstrated affective realism by showing that a

perceiver's affect influence social perception. In this series of studies, we demonstrated that affective realism influences judgments with real-world consequences, like guilt/innocence. We showed that affective realism is powerful enough to change a perceiver's experience of an explicitly smiling or scowling face. And we also showed that affective realism is enhanced when people are viewing unfamiliar faces from another culture.

Contributions to Basic Research

This research has broad theoretical significance. First, our work demonstrates that all of us are active perceivers. We don't passively detect information in the world—we actively construct perceptions of the world. We are the architects of our own experience. As perceivers, we do not come to know the world through only our external senses—we see the world differently when we feel pleasant or unpleasant. In particular, our work is moving beyond just demonstrating this effect to examining its mechanisms, boundary conditions, and applications.

Second, we will eventually be able to measure and model individual differences in affective realism based on whether someone is prone to frequent and strong changes in affect (affective reactivity) and the ability to perceive changes in body state (interoceptive sensitivity). For example, individuals with intense affective reactivity may literally see the world differently. A person whose perceptions are affectively infused might experience a very different world than someone with less affective infusion. It is very possible that certain types of life experience (e.g., protracted engagement in combat with few breaks, prolonged threat of social evaluation, sleep deprivation,

consistent social support, cultivating unit cohesiveness, etc.) can wire the brain to see things that precipitate (or protect against) psychological distress, making certain people more susceptible to (or more resilient to) a host of interpersonal difficulties and illnesses.

Fourth, our ongoing research suggests that that there is a role for affect in the conviction with which people hold their beliefs. Affective realism lends a sense of validity and force to people's attitudes and beliefs about others and provides a sense that what they know is right or correct. As such, we hope our ongoing research will set the stage for future studies on how affect contributes to confidence in beliefs about political topics, world-view and religious faith, providing another avenue for exploring the ease and effectiveness with which people interact with others who do not share their own views. In this way, the present research has implications for understanding the role of affect in cross-cultural negotiation and conflict resolution.

Finally, these studies provide an excellent behavioral platform for studying the location and timing of the neural processes that underlie the role of the perceiver's affective state in affective realism; this would be a topic of future research. In fact, we have been developing a brain-based model to explain how the brain creates affective realism and why it can be such a potent force in determining perception and behavior.

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 these 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 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 determine who will benefit most from affective calibration training (making this work also potentially relevant to basic research interests to support training that increases the ability to detect threats quickly and accurately). The 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 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 react more effectively in given situations and in times of duress or peace, be it towards comrades/enemies or superiors/subordinates. Such self-awareness will enhance the Soldier's ability to be more flexible and adaptable in novel situations, critical to both the Soldier's and the 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 hope to eventually extend this work to targets from a wider variety of racial and cultural backgrounds than those explored in the present study (e.g., Middle Eastern, Mexican, Chinese). These studies will allow us to examine whether gut feelings are more or less likely to influence the perception of diverse targets.

Additionally, in we refined our individual differences battery to use in a follow up grant mapping variability in emotional experiences both within and across individuals as they occur in the context of everyday life, including both self-reported emotional experiences and measures of bodily activity thought to be associated with emotional experience and responding (e.g., heart rate, sweat gland activity, respiration rate, etc.)

The goals of this follow-on project are to identify new biologically-based categories of experience, examine whether these categories generalize across people, and examine whether they can improve prediction of changes in decision making under experiences of heightened or intense emotional experience both within and across individuals.

Associated Publications

- Kleckner, I. R., Wormwood, J. B., Simmons, W. K., Barrett, L. F., & Quigley, K. S. (2015). Methodological recommendations for a heartbeat detection-based measure of interoceptive sensitivity. *Psychophysiology*, 52(11), 1432-1440.
- Wormwood, J. B., Neumann, A. E., Barrett, L. F., & Quigley, K. S. (2017). Understanding emotion in context: how the Boston marathon bombings altered the impact of anger on threat perception. *Journal of Applied Social Psychology*, 47, 13-22.

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