TESTIMONY

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and

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Chairman Smith, Chairman Baird, and distinguished members of the Subcommittees, thank you for this opportunity to discuss the social, behavioral and economic (SBE) sciences and the military. I am Mark Weiss, the Division Director for Behavioral and Cognitive Sciences within the Directorate for Social, Behavioral and Economic Sciences at the National Science Foundation (NSF). In this capacity, I oversee programs that fund research in branches of psychology, geography, anthropology and linguistics.

The social, behavioral and economic sciences, or what we also call the human sciences, are concerned with human actions at every level, from an individual's brain, to individual behavior, to the actions of social groups and organizations. Because warfare is a human activity, there are deep and compelling reasons for the military to be cognizant of research in the social and behavioral sciences. From fighting the war on terrorism to understanding and overseeing an immense organization, the SBE sciences can provide military policymakers with knowledge-based solutions to critical challenges.

The federal support of basic research in the social, behavioral and economic sciences is largely funded by NSF through grants to researchers, most of whom are located at academic institutions within the United States. Much of the SBE research carried out by NSF's principal investigators would appear to be either directly or indirectly of interest to the military.

In this testimony, I will first describe the role that NSF plays in advancing basic research in the social, behavioral and economic sciences. Second, I will address the questions received in the invitation from the Subcommittees. It is my hope that my responses to your questions will provide insight into the benefits that the military may realize as a result of NSF's investment in SBE research. I have included examples of opportunities for SBE data, findings and methods that may assist the military in meeting its missions and goals, and means by which collaborations may be nurtured or enhanced.

The Human Sciences

The social, behavioral and economic sciences comprise several different disciplines focused on one common goal: a deeper understanding of human beings at every level. Among the participants are: *anthropologists* studying the workings of cultures and societies; *neuroscientists* and *psychologists* probing the inner workings of the mind and brain; *linguists* seeking the neural basis of language; and *economists*, *political scientists*, *sociologists* and *geographers* mapping the forces at work in today's societies. These researchers study team building, risk management, metrics for assessing U.S. competitiveness, brain function, disaster response, radicalization, the dynamics of conflict, decision making, and much more.

In recent decades, SBE research supported by NSF has resulted in new understandings of human development and social dynamics; of perception, memory, linguistic, and reasoning processes; of how people behave as individuals and collectively; and insight into economic systems. SBE-supported research projects that have resulted in new knowledge, innovations and discoveries that directly benefit the public and inform policy makers. For example, NSF-supported economists provided the Federal Communications Commission with its current "spectrum auction" system for apportioning the airwaves. The auctions have netted over $45 billion in revenue for the federal government since 1994. Other SBE-supported research on decision-making regarding influenza vaccinations has elucidated that persons aged 65 and older were most likely to get influenza vaccinations, while immunization rates for the young were very low. Unfortunately, however, the young, who are choosing not to get vaccinated, are disproportionately responsible for spreading the flu. Thus, community-wide vaccination programs would be more effective in reducing the spread of flu than an approach of targeting specific age groups.

SBE research projects can also directly inform DoD efforts. For example, a study at the University of California at Irvine says stress and fear in the aftermath of the Sept. 11, 2001, terrorist attacks on the World Trade Center and the Pentagon may have prolonged health effects for Americans. For the first time, researchers have evidence that high levels of mental and emotional stress from traumatic events may be linked to an increase in cardiovascular problems among those with no personal, direct exposure to the conditions that caused the stress. Another recent project found that intermediate levels of political freedom and geographic factors

contribute significantly to causes of terrorism, challenging the common view that terrorism is rooted primarily in poverty. A public policy professor at Harvard University's Kennedy School of Government reviewed the World Market Research Centre's Global Terrorism Index and found no clear correlation between terrorism and poverty. Of the research supported within NSF's SBE Directorate, we estimate that approximately 10-15% might be of clear and immediate interest to the military.

It is also important to realize that over recent years, researchers from many domains of science and engineering have developed new tools and approaches that have transformed the SBE sciences. Networked computing, functional MRI brain scanners, geographical information systems, DNA analysis and computer-enhanced surveys all have played roles in transforming the theories and methodologies of the human sciences. Interdisciplinary collaborations are increasingly the norm, with links formed among members of SBE science communities and between SBE scientists and researchers in other fields such as computer science, engineering, mathematics and biology.

The quest for a deeper understanding is also key to managing society's and the military's most critical challenges, which include fighting fanaticism, extremism and terrorism around the world. While it is tempting to pursue purely technological interventions and solutions to these challenges, technology alone cannot provide answers because there is an inescapable human element, which must be appreciated and addressed through the perspectives and approaches of the human sciences.

The Unique Role of the National Science Foundation and the SBE Sciences

NSF is the only federal agency dedicated to supporting fundamental research and education across all fields of science and engineering and at all levels of education. The Foundation's vision, "advancing discovery, innovation and education beyond the frontiers of current knowledge, and empowering future generations in science and engineering," is captured succinctly in the FY 2006-2011 Strategic Plan, *Investing in America's Future.* For more than 50 years, NSF has had an extraordinary impact on the nation's scientific knowledge and capacity.

NSF provides nearly half of the total federal support for non-medical basic research conducted at America's colleges and universities. However, NSF provides a far greater percentage of the support for basic research within many of the human sciences. Approximately 60% of federal support for basic research in anthropology, social psychology and the social sciences at U.S. academic institutions comes from the SBE Directorate at NSF. For some SBE disciplines, NSF supplies more than 90% of the funding for basic research.

NSF invests heavily in competitive merit evaluation based on peer review in order to ensure that the highest quality basic research is funded. As a result of constant deliberation and refinement, NSF's peer-review process is broadly acknowledged to provide the gold standard for merit evaluation. The United Arab Emirates, Saudi Arabia, Turkey, France, and Ireland, among others, are emulating the NSF model.

One indicator of the SBE Directorate's success at identifying and supporting transformative research is that every Nobel laureate in economics since 1998 has been an NSF awardee. Since 1990, 30 of the 35 U.S.-based scholars who have won the Nobel Prize in Economics received funding from NSF.

There is an increasing appreciation of the benefits of interdisciplinary research; a circumstance that precipitates new thinking as scientists approach a common problem with different assumptions, data, methods and perspectives. Indeed at the forefront of the trend towards collaboration across the full range of sciences, the Foundation's priority area in *Human and Social Dynamics* requires interdisciplinary collaborations. Many of the researchers funded through this program are pursuing topics that have clear implications for the military, such as research to understand radicalization, the dynamics of conflict, and disaster response.

A particularly important feature of NSF is its flexibility. NSF's core activity is the support of high quality scientific research. Numerous methods are in place to accomplish this goal, and business processes can be modified to accommodate specific requirements. This makes NSF an ideal partner for establishing new relationships. Innovative solicitations, memoranda of agreement and cooperative funding are routinely implemented.

NSF also has very strong ties to the academic community. Leading experts from academe serve as a central corps for NSF's merit-review system. Scholars provide written reviews, serve on review panels and advisory committees, and participate in workshops. The latter is a particularly productive mechanism for initiating and informing the development of new research themes.

The National Research Council Report and NSF Support of Recommended Research

The U.S. Army Research Institute for the Behavioral and Social Sciences asked the National Research Council "…to provide an agenda for basic behavioral and social research focused on applications in both the near term (5-10 years) and far (more than 10 years) term." The report, "Human Behavior in Military Contexts," details a series of recommendations regarding SBE research that would be applicable to military needs.

Six major research areas with high potential impact were highlighted: (1) Intercultural Competence; (2) Teams in Complex Environments; (3) Technology and Training; (4) Nonverbal Behavior; (5) Emotion; and (6) Behavioral Neurophysiology. Each is relevant to the military in a variety of areas including leadership, training, personnel, social interactions and organizational structures. Interactions between NSF and the military may be one mechanism for achieving the goals described in the report.

NSF supports significant levels of basic research in all of these areas. One can point to specific NSF disciplinary and interdisciplinary programs and provide numerous illustrations. Let me provide several examples of recent NSF/SBE awards that involve each of the research themes highlighted in the NRC report. These examples by no means delineate the boundaries of NSF's support of basic research in these areas; rather, they are specific examples from very large bodies of supported research.

Intercultural competence: Scott Atran and colleagues at the University of Michigan received an award (NSF award #0527396) to study human behavior motivated by ethical or religious beliefs. The hypothesis of this research is that religious or moral values play important roles in creating culturally distinct political and resource-management systems. But current conflict management approaches often assume strictly rational choices among the adversaries, even though cultural choices may frequently be based on ethical or religious beliefs that are not shared or understood by the conflicting cultures. This research has far-reaching implications for military operations in regions where religious beliefs heavily influence local cultural and political systems.

Teams in Complex Environments: The Social Psychology and Decision, Risk and Management Sciences programs jointly fund research (NSF award #0744696) by Susanne Abele (Miami University) to study "Coordination in Small Groups: Matching and Mismatching." This research explores the coordination of behavior of groups during problem-solving. The project places subjects into situations in which they will either match or mismatch their behavior to achieve an outcome. In matching, it is mutually beneficial for actors to choose the same action. In mismatching, it is mutually beneficial for actors to choose different actions (e.g., divisions of labor in teams). Matching and mismatching behaviors are expected to result in different interpersonal impressions and feelings. The planned experiments will examine the conditions under which coordination does and does not foster group cohesion. The results of this type of research are directly applicable to the social dynamics of the types of groups found in the armed services.

Technology and Training: NSF utilizes a number of mechanisms to fund transformative research. One is the establishment of centers which focus knowledge and resources upon a broad challenge facing the nation. The SBE Directorate manages such an effort to create the intellectual, organizational and physical infrastructure needed for the long-term advancement of science-of-learning research. Centers harness and integrate knowledge across multiple disciplines to create a common groundwork of conceptualization, experimentation and explanation that anchor new lines of thinking and inquiry towards a deeper understanding of learning.

There are now six centers, each focused on a different aspect of the science of learning. For instance, the Learning in Informal and Formal Environments (LIFE) Center is an interdisciplinary collaborative effort between scientists at the University of Washington, Stanford University and other institutions (NSF Award #0354453). Its goal, unlocking the powers of human learning in informal and formal settings across the life span, will provide valuable insights to any organization that trains an ethnically diverse population of young adults in complex tasks, such as the U.S. military.

Another example is the Spatial Intelligence and Learning Center, a collaborative effort of scientists at Temple University, Northwestern University, the University of Chicago, University of Pennsylvania and the Chicago Public Schools (NSF Award #0541957). Its overarching goal is to understand spatial learning, and to utilize this knowledge to develop programs and technologies that will transform educational practices. One of their initial tasks is the development of instruments for the assessment of spatial skills.

Emotion: Emotions play a key role in individual perceptions, cognition, motivation and identity formation, while also influencing social interactions and behavior. Recent advances in new technologies such as infrared thermography are being tested as methods for assessing different emotional states by measuring changes in facial temperature. University of Georgia researcher Dawn Robinson explores the connections between different emotional states using facial thermography (NSF award #0729396). Robinson aims to use the technique to discriminate between different emotional states, and to test the sequencing of emotions in social interactions. By measuring relative temperature across different regions of the face, Robinson suggests that the core dimensions of emotion – affect, potency and activity – can be measured. Subsequent experiments will use these new techniques to measure changes in emotional states during on-going interactions; thus, testing theoretical predictions about the sequencing of emotions that individuals experience when moving from one emotional state to another. Ultimately, this work should help advance knowledge about emotions in social interactions.

Nonverbal Communication: NSF supports research through a number of SBE programs, often with co-funding from across the Foundation, which provides insights into the complex individual and group dynamics of human communication and behavior. Humans communicate and share information in a variety of nonverbal ways, picking up on behavioral cues and gestures during face-to-face communication, including the detection of deception, as well as through various types of interactions in computer-mediated environments.

For example, Paul Torrens from Arizona State University (NSF award #0643322) is developing highly sophisticated computer-based models that can provide insights into the ways that individual actions affect behavior on all levels in large group settings. In one set of experiments, Torrens and his students have examined emergency evacuations. They found that subtle stop-and-start movement amid a panicked crowd manifests as ripples in individual behavior. These ripples spawn larger waves, which then wash through the crowd, causing further obstructions and ultimately large-scale congestion. This type of sophisticated agent-based modeling capitalizes on recent advances in computational capabilities and visualization, providing new and innovative tools for research in the SBE sciences.

Behavioral Neurophysiology: The Cognitive Neuroscience Program is one example of an NSF program that supports research on thought, perception, affect and action in the human brain. In one example, John Foxe at CUNY City College is studying the neurophysiology of attentional deployment (NSF award #0642584). He and his team are investigating the ability to selectively attend to "relevant" elements of our environment while ignoring irrelevant or distracting information, a skill that is important in everyday life, but is of supreme importance in a military setting. Two basic neural mechanisms for this selectivity have been proposed. It may be that excitability in those neurons responsible for processing stimuli of interest is selectively enhanced. Alternatively, excitability in neurons receiving inputs irrelevant to the task at hand may be suppressed. Using a novel set of electrophysiological tools, Foxe will begin to determine the relative importance of these two mechanisms.

Additional Near and Far-Term SBE Research with Potential Military Applications and Funding Considerations

One emerging field of science that is of interest to both NSF and the military seeks to optimize human-machine interaction. The technological capabilities of robotic and 'smart' instruments are still far exceeded by those of the human brain. The development of the next generation of intelligent devices will likely benefit greatly from incorporating the human brain's perceptual abilities, high learning rates and ability to generalize. This requires a brain-machine interface that will sample and process neuronal activity in real time. For example, Miguel Nicolelis at Duke University has shown that a monkey can focus its brain activity in order to control a robotic arm and a walking robot.

Exploiting human design in human-machine interactions will require substantial progress on several multidisciplinary fronts. To that end, NSF proposed a $15-million interdisciplinary investment in Adaptive Systems Technology in FY 2009. This new activity will focus on generating creative pathways and natural interfaces between human and physical systems in order to enhance novel adaptive systems. Needed on the technological side is the development of a lightweight, wearable, wireless multi-channel technology for transmitting brain activity to a remote receiver. Pattern-recognition algorithms must be designed and tested for analysis of the complex patterns of brain activity needed for intelligent, interactive control. On the human side, we need to understand the dynamics of brain activity and its individual variation in people.

Many other research areas are imaginable. Ubiquitous computing and related technologies (cell phones, PDAs, email, the Web, etc.) generate immense volumes of interaction records. For example, research published in the 2007 *Proceedings of the National Academy of Sciences of the USA* entitled, "Structure and tie strengths in mobile communication networks," used mobile phone records from a "moderate-sized European nation" to examine the structure of networked interactions and patterns of communication and dissemination. The data set included 7 million phone users and produced 49 trillion dyads for analysis. The data are overwhelming in volume and resolution, and the techniques are novel and dependent on new technologies. With proper attention to confidentiality concerns, research in such areas could be of significant interest to the military.

If DoD wishes to support fundamental research involving the human sciences, the formulation of specific solicitations could also be discussed. For example, SBE was an active partner in a solicitation entitled, "Explosives and Related Threats: Frontiers in Prediction and Detection." This solicitation was coordinated with DoD and leveraged research underway in other areas of the Federal government. Awards that involved SBE scientists included ones that are testing new approaches to the study of threat detection, including the effect of the observer's emotional status on his or her ability to interpret the intentions of another, and improving the effectiveness of explosive-detection dogs through the use of temperament-based selection.

The DoD may also choose to support select NSF-SBE research proposals of interest. For example in FY 2007, the Director of National Intelligence's (DNI) Office of Integrity and Standards transferred $1.3 million to NSF to support 10 research awards aimed at developing new capabilities and techniques to improve the ability of intelligence-community analysts to understand, process and communicate information. Prior to DNI determining which proposals to fund based on their research goals, the proposals were rated and determined meritorious via NSF's peer-review process.

The Current NSF-SBE Directorate and DoD Relationship

Currently, no formal agreements exist between the NSF/SBE Directorate and the DoD. However, a number of informal channels and networks, illustrated via the following list, facilitate communication between the two organizations:

- David Lightfoot, Assistant Director for Social, Behavioral and Economic Sciences is Co-Chair of the National Science and Technology Council's (NSTC) Subcommittee on Social, Behavioral and Economic Sciences. The Department of Defense is represented on the subcommittee.

- The SBE Directorate was integral to the development and conduct of the "Explosives and Related Threats: Frontiers in Prediction and Detection" solicitation. This effort was coordinated with the Department of Defense.

- Several program officers within the directorate have informal connections with colleagues in various units of the Department of Defense.

- NSF is represented on the newly established Subcommittee on Human Factors for Homeland and National Security of the NSTC Committee on Homeland and National Security.

- NSF/SBE and DoD personnel are both participants in informal interagency networks, such as the "Socio-Cultural and Behavioral Science Research Group."

- NSF/SBE program officers have participated in several DoD-sponsored conferences.

- Occasionally NSF/SBE program officers have reviewed research proposals submitted to DoD programs such as "National Security Science and Engineering Faculty Fellowships."

NSF's Activities of Value to DoD & Joint NSF-DoD Research Opportunities

Many DoD personnel may benefit from increased awareness of NSF's programs and research. Increased communication between NSF and DoD may inform a wider audience about the activities of the Foundation that could benefit DoD, and likewise, educate NSF staff on DoD's objectives and research needs. For example, including NSF personnel in select aspects of the DoD Quadrennial Defense Review assessment might provide one venue for educational interchange.

NSF has coordinated with the military in the construction of solicitations, although rarely have these involved SBE. With the increasing appreciation of the benefits that accrue to the military from basic research in the human sciences, such interactions could be expanded. Even in the absence of joint solicitations, NSF can provide expertise in the process of merit-based peer review.

NSF's primary contacts are with academic communities of scholars and researchers. Through these links, the Foundation could help to increase discussion of basic research topics of interest to the military. Models for doing so exist, most notably the support of workshops and symposia.

Most importantly perhaps, NSF could provide the military with a broader perspective on the potentials of SBE research. The results of basic research can be broadly adapted to contexts unrelated to the specific context of the original research. Thus, the findings of basic research conducted in non-military contexts may often be directly transferable to military situations.

As a mission agency, DoD funds investigations that are focused upon national security goals. NSF program officers, on the other hand, see proposals and findings of research on a broader front. This perspective provides a larger picture of activity in human science research, as investigations initiated in one sphere may ultimately lead to research applicable in a military setting.

Conclusion

Mr. Chairmen, I've touched on just a handful of activities and projects found in NSF's diverse and vibrant SBE research portfolio. I hope that I have been able to articulate NSF's unique role in supporting fundamental SBE research and value-added that NSF-supported SBE research may provide to the military community. Thank you for the opportunity to appear before you, and I am happy to answer any questions you may have.

About Dr. Mark L. Weiss

Dr. Mark Weiss is Director of the Behavioral and Cognitive Sciences Division at the National Science Foundation. This division is housed within the Directorate for Social, Behavioral and Economic Sciences. Prior to joining NSF, Dr. Weiss was Professor and Chair of the Department of Anthropology at Wayne State University. Starting in 1990, Dr. Weiss served as Program Director for Physical Anthropology at NSF. He served in this capacity for three rotations during the 1990s until becoming a permanent employee in 2000. In 2005 Dr. Weiss served as Assistant Director for Social, Behavioral and Economic Sciences at the Office of Science and Technology Policy in the Executive Office of the President. Upon returning to NSF, he served as both the Senior Science Advisor in the SBE Directorate and also as Deputy Assistant Director of the Directorate.

Dr. Weiss' research expertise has been in the application of genetic approaches to the study of nonhuman primate evolution and behavior. His most recent publications focused on the evolution of molecules involved in the generation of energy in the human brain.