Response to Senator Lankford's "Federal Fumbles"

The National Science Foundation (NSF) has been the backbone of America's science and engineering research enterprise for more than sixty years. In fact, NSF is the only federal agency that supports all fields of fundamental science and engineering research and education. NSF supports cutting-edge research projects—many of which serve as bellwethers for solutions to the myriad complex issues facing society. NSF programs also traditionally integrate research and education, fast tracking innovation excellence via hands-on learning to train our next generation of researchers and innovators.

Each year, NSF competitively awards thousands of grants that collectively advance our nation's scientific capabilities and engage the talents of hundreds of thousands of researchers, postdoctoral fellows, technicians, teachers and students in every field of science and engineering. NSF is the primary source of federal funding for non-medical basic research, providing approximately 12,000 new awards annually.

Through its merit review process, NSF ensures that proposals submitted are reviewed in a fair, competitive and in-depth manner. Competition for funding is intense, with only about one out of five proposals ultimately being approved.

Each proposal submitted to NSF—including those deemed "wasteful" and "out-of-touch" in the "Federal Fumbles" report (authored by Senator James Lankford)—is reviewed by science and engineering experts well-versed in their particular discipline or field of expertise. All proposals submitted to NSF are reviewed according to two merit review criteria: Intellectual Merit and Broader Impacts. Nearly every proposal is evaluated by a minimum of three independent reviewers consisting of scientists, engineers and educators who do not work at NSF or for the institution that employs the proposing researchers.

On average, roughly 50,000 experts share the benefit of their knowledge and give their time to serve on review panels each year. NSF selects reviewers from the national pool of experts in each field, and their expert evaluations are confidential. NSF's merit review process is considered by some to be the "gold standard" of scientific review. Perhaps the best evidence of NSF's success is the repeated replication of its model for discovery, education and innovation in nations around the globe.

The results of this process—funding the best and brightest ideas through competitive merit review—have been profound. NSF-supported research has underpinned multitudinous discoveries—the Internet, Web browsers, Doppler radar, Magnetic Resonance Imaging, DNA fingerprinting, and bar codes—to name a few. These diverse examples underscore NSF's significant contributions to our nation's prosperity, health and well-being. NSF-funded

discoveries have expanded our understanding of the world in which we live, led to life-saving-medical advances, enhanced our national security, improved our everyday lives and yielded insights into the creation of the universe.

Yet, a simple truth remains regarding fundamental scientific breakthroughs: Before these discoveries were made, these ideas, too, might have been considered novel or outside-of-the-box. Sometimes, based solely on the title of the project, these ideas might have even seemed impractical or inappropriate at first glance. However, if one used project titles instead of merit review to make funding decisions, Google® might not exist today. What was the original name of this search engine when it was funded as an NSF Digital Library project? BackRub.

Technical titles might also easily be misconstrued by anyone but a scientist or engineer versed in technical jargon. For example, a NSF-funded award titled, "Implementation of Maximum Likelihood Decoding for Trellis Codes and Trellis Coded Modulation," actually led to the development of an electronic chip that enables mobile communications worldwide. Who knew "trellis codes" was slang for what would became one of the the most important technologies underpinning global wireless communication, an innovation vital to Qualcomm, a world leader in next-generation mobile technologies? These examples highlight the problem with discarding a project based solely on its title.

Moreover, the ripple effect of fundamental research can rarely be anticipated. Fundamental social and economic research on "game theory" revolutionized the way our nation apportions its airwaves, resulting in $60 billion for the U.S. Treasury derived from spectrum auctions. In this particular case, the link between fundamental research and direct application was unclear—until it offered the Federal Communications Commission a viable solution for partitioning our wireless bandwidth.

NSF's task of identifying and funding work at the frontiers of science and engineering requires keeping close track of research around the United States and the world; maintaining constant contact with the research community to advance the horizons of inquiry; and choosing the most promising people to conduct the research. The following summaries of the six projects highlighted in "Federal Fumbles" illustrate examples of promising NSF-funded research that were awarded support through the merit review process.

An aging population, rising healthcare costs, and a shortage of healthcare workers has created a pressing need for affordable and effective personalized care. This research seeks to create mechanical aids for people who have difficulty dressing themselves. The physical task of putting on a shirt or another article of clothing can be difficult or impossible if one has limited movement in an arm or a leg. People who may be in need of such help include the elderly, wounded veterans, and people who have suffered a stroke.

The research has nothing to do with picking out clothes. Rather, it is designed to enable robots to provide physical assistance with the act of putting on an article of clothing. Within healthcare, dressing oneself is widely recognized as a basic self-care activity that is important for quality of life and living independently. Many people lose the ability to dress themselves due to injuries, illnesses, and impairments, including impairments associated with aging. Much as wheelchairs are assistive devices that enable people to move themselves from place to place, robots might serve as assistive devices that enable people to perform other important tasks for themselves.

It is difficult to appreciate the need for such assistance if you are a fully able-bodied person. To understand the issues involved, imagine that you have lost the ability to bend, raise, or grip with your dominant arm. Now, imagine putting on each of your articles of clothing with this physical difficulty, every day of your life. This research seeks to create a mechanical system that can be optimized based on what a particular human with impairments is capable of doing comfortably.

This is significant for several reasons. This research uses efficient physics simulation and optimization tools to substantially automate the design of assistive robots. These capabilities critically depend on advancements in the efficient physical simulation of cloth, robots, and humans, as well as the discovery of appropriate human motions for a given assistive robot – all of which has the potential to result in better computer tools for fruitful collaborations between robots and humans in other scenarios, that go beyond dressing. Maintaining independence and cutting the cost of continuing health care for an aging population are both key potential outcomes of this research.

A New Design for Identifying Persuasion Effects and Selection in Media Exposure Experiments via Patient Preference Trials
NSF Award 1528487
Page 37: "Which Came First, the Chicken or the Egg?"
Massachusetts Institute of Technology

Many researchers have considered whether media choice causes polarization or if polarization causes media choice. However, this project attempts to advance those previous studies and develop a better **method** to understand how the media influences political attitudes and behavior. By combining the participant preference experiment – "free-choice" – with a selective exposure design – "forced-choice" – the research effectively address the weaknesses each theory when used separately. This approach will be of broad interest to other social scientists, who must manage selection bias and reciprocal relationships.

The research has the potential to transform the way scholars and practitioners study the influence of media on public opinion. The measurement of media effects has broad applicability to a variety of research areas, including U.S. foreign policy. For example, understanding how people in other countries might choose media outlets based on their sentiment toward that source rather than the ability of that source to persuade them has important implications for U.S. policy makers. Additionally, the researchers are developing public-use software to make their analysis tool widely available for scholars in many fields to study topics with similar inferential challenges.

Understanding the Mechanisms for Disengagement from Contentious Political Interaction
NSF Award 1423788
Page 75: "Government Studies Old Cliché"
College of William and Mary

This research attempts to fill major gaps in political science literature by examining the psychological traits that impact our willingness to engage in political debate.

The combined effect of increased social interaction regarding politics – due largely to the development of the Internet and social media – in a more polarized political environment suggests that today people are more likely to encounter extreme views, information about political beliefs in their social connections, and demands to voice their own political opinions. Not everyone will be equally affected by these changes in the political environment, however. Individual psychological differences may influence how people interpret and respond to the contentious social interactions about politics.

Democracies rely on all citizens having equal opportunity to voice their opinions. However, subtle, and perhaps more complex barriers to political engagement may be influenced by an individual's orientation toward conflict and disagreement. People who prefer consensus and compromise may be discouraged from engaging meaningfully with politics in a polarized environment.

Identifying the facets of politics that are stressful to citizens will help researchers understand what may incite some people to engage more directly in the political process – or withdraw. However, the results of this research go beyond political engagement; social psychologists are interested more generally in the connection between stress and participation/engagement.

Understanding Age-Related Changes in Relationship Maintenance Strategies
NSF Award 1451492
Page 77: "Fed Study on the Ups and Downs of Senior Dating"
University of Texas at Austin

The health and welfare of older adults is a huge economic concern for our country. There is evidence that loneliness in elderly individuals is linked to chronic disease and mortality. For instance, a very recent longitudinal study[1] of adults indicates that loneliness seems to be associated with biological changes (activity of genes involved with inflammation and immunity, plus hormone levels that affect these as well). These findings suggest how social relationships may influence susceptibility to negative health consequences.

A wealth of research indicates that high quality romantic relationships allow individuals to thrive both emotionally and physically. In fact, the impact of close relationships on health has been shown to be larger than the impact of a variety of negative health behaviors, such as smoking, excessive drinking, and obesity. Longer life expectancies and high divorce rates have contributed to older adults increasingly finding themselves unpartnered and searching for companionship.

Although there is a body of research regarding the relationship processes that create a happier, healthier relationships, this literature has focused overwhelmingly on relationship formation in **young adults,** or longstanding marriages, leaving open questions regarding the generalizability of these findings to an older population in newly-formed relationships. Thus, the proposed research is designed to fill this gap and will inform improving happiness and health throughout the lifespan.

The goal is not to help seniors improve their dating, and to serve as a "match.com" for seniors. The goal is to redress a theoretically important, and societally-important gap in the literature about social bonds, by testing key theoretically-grounded hypotheses about how dating processes in older adults might differ in crucial ways than in populations that have been much more widely studied.

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[1] Recent PNAS paper, accepted October 2015 (Cole, Captianio, Chun, Arevalo, Ma & Cacioppo): http://www.pnas.org/content/early/2015/11/18/1514249112.abstract.

I-Corps Program Background

The mission of the National Science Foundation's (NSF) Innovation Corps (NSF I-Corps™) program is "to foster entrepreneurship that will lead to the commercialization of technology that has been supported previously by NSF-funded research."

Through I-Corps, researchers learn the entrepreneurial skills required to successfully translate university-based, complex and fundamental research into the marketplace. The NSF I-Corps program is geared towards scientists and engineers who have, through NSF basic-research funding, discovered something in their laboratory that has commercial appeal that may benefit the U.S. economy. This program has been supported by federal legislators and is currently being emulated at other federal agencies, and around the world.

I-Corps: Practical and Provably Secure Random Number Generator
NSF Award 1464476
Page 38: "Casinos Could Hit Jackpot from Taxpayer-Funded Research"
University of Michigan, Ann Arbor

This goal of this work is to extend and explore commercialization of the researcher's previous work in quantum physics to generate random numbers that can be assured to be truly random. High quality random numbers are critical to nearly all forms of modern computing systems, including securing credit cards, electronic commerce, banking, and health care privacy.

However, most so-called "random" numbers are not actually random, and if they can be predicted, they can be used to compromise computing systems. For example, a recent compromise of all government-issued IDs in Taiwan was traced to a poor quality random number generator. Some parts of the gambling industry use high quality random numbers, but that is only one industry sector that would benefit from such technology. Major corporations such as Intel and Amazon and large banks are just a few examples of organizations with a strong need for digital security. Transitioning this research through the I-Corps program into commercial products will protect Americans, the U.S. government, and American businesses, contributing to our economic vitality and national security.

Through I-Corps, NSF has been cultivating a pipeline of university-based researchers who can turn ideas into successful commercial products, and equipping our nation's science and technology faculty and students to be creative, entrepreneurial leaders. For this researcher, the I-Corps process was the next critical step to make the business case around the current science clear enough, so that potential customers would be willing to privately fund the continued development and ultimate application of the product. This award provided additional mentoring support to accelerate innovations that can attract subsequent third-party funding. The hope is that the I-Corps process can accelerate the development of this business case and ensure that government-funded basic research is successfully transitioned to the marketplace.

Strategies to increase U.S. rankings in STEM education have largely focused on improving the rigor in STEM content matter. However, recent studies have indicated it is not *what* we teach, but *how* we teach that may have the largest effect on student learning, particularly as it pertains to STEM subjects.

This I-Corps project addressed how to engage STEM learners effectively. Funding from this I-Corps award has led to the establishment of a company, Killer Snails, LLC and was advancing previous computer science research funded by NSF. Killer Snails, LLC is a learning game company that uses extraordinary creatures found in nature to advance STEM learning. Killer Snails (KS) learning games combine the compelling content of predatory marine snails that use venom to capture prey, with leading edge assessment tools, and a proprietary assessment dashboard, to provide student players and parents with effective methods for enhancing STEM learning. "Serious games" are games designed to simulate real world experience and teach players a new skill.

Unlike the Small Business Innovation Research Program, which supports an existing small business to conduct early concept research, the I-Corps program supports teams of scientists and engineers who are investigating the potential of their discovery to *become* a small business. By supporting this I-Corps proposal the NSF has enabled a team of scientists to create a product that U.S. teachers, parents, and students can use to improve STEM learning.