

SOCIAL AND BEHAVIORAL SCIENCES FOR NATIONAL SECURITY

Proceedings of a Summit

Julie Anne Schuck, *Rapporteur*

Board on Behavioral, Cognitive, and Sensory Sciences

Division of Behavioral and Social Sciences and Education

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Preface

In the coming years, complex domestic and international environments and challenges to national security will continue. Intelligence analysts and the intelligence community will need access to the appropriate tools and developing knowledge about threats to national security in order to provide the best information to policy makers. Research and knowledge from the social and behavioral sciences (SBS) can help inform the work of intelligence analysis; however, in the past, bringing important findings from research to bear on the day-to-day work of intelligence analysis has been difficult.

With generous support from the Office of the Director of National Intelligence (ODNI), the National Academies of Sciences, Engineering, and Medicine will undertake a 2-year survey of the social and behavioral sciences to understand how knowledge from science can be directed and applied to help the intelligence community fulfill its critical responsibilities. A robust discussion between the academic and intelligence communities is needed to accomplish this task.

To launch this discussion, a summit was held on October 4-5, 2016, in Washington, DC. The National Academies, through its Board on Behavioral, Cognitive, and Sensory Sciences (BBCSS), assembled a steering committee to plan, identify presenters, and host the summit. The summit brought together academics, members of the intelligence community, and representatives from the government for a day and a half to explore a few of the new developments in SBS research and the relevance of such work to intelligence analysis.

On behalf of the committee, I give special thanks to David Honey, director of science and technology at ODNI, for his vision and determina-

tion to undertake this survey study and resolution to hold such a summit to kick off the study. We also thank Kent Myers, senior consultant at ODNI, for serving as a liaison between the National Academies staff and the intelligence community during the preparations for the summit.

The success of the summit was due in great part to the guidance and insight of the steering committee and the invited presenters, who took time out of their schedules to present their research programs and engage in conversations with other presenters and attendees. First, let me extend my thanks to other workshop steering committee members, who lent their own expertise to the summit preparations and discussions: Thomas Fingar, Stanford University; Steven Hyman, Harvard University; Valerie F. Reyna, Cornell University; and Philip E. Tetlock, University of Pennsylvania. We would also like to thank the following invited speakers for their presentations at the summit: David Broniatowski, George Washington University; Mathew Burrows, Atlantic Council; David Cesarini, New York University; Joshua Epstein, Johns Hopkins University; Susan Fiske, Princeton University; Charles R. Gaukel, National Intelligence Council; George Gerliczy, Central Intelligence Agency; Paul Glimcher, New York University; Read Montague, Virginia Polytechnic Institute and State University; Benjamin Neale, Harvard Medical School; Elizabeth Phelps, New York University; Paul Slovic, University of Oregon; Geoffrey Strayer, Defense Intelligence Agency; and Jeremy Wolfe, Brigham and Women's Hospital, Harvard Medical School.

The summit would not have come together so quickly and with so much promise for the study to come without the support of the National Academies staff. We offer special thanks to Barbara Wanchisen, BBCSS director; Sujeeta Bhatt, study director; and other members of the project team: Julie Anne Schuck, Elizabeth Townsend, Hannah During, and Renée L. Wilson Gaines. In addition, Viola Horek and Doug Sprunger helped manage the fast turnaround on the communications around the summit. Yvonne Wise and Eugenia Grohman provided valuable help with the editing and production of these proceedings, and Kirsten Sampson Snyder managed the report review process.

This workshop proceedings has been reviewed in draft form by individuals chosen for their diverse perspectives and technical expertise. The purpose of this independent review is to provide candid and critical comments that will assist the institution in making its published report as sound as possible and to ensure that the report meets institutional standards for objectivity, evidence, and responsiveness to the charge. The review comments and draft manuscript remain confidential to protect the integrity of the process.

I thank the following individuals for their review of this report: Bear F. Braumoeller, Department of Political Science, The Ohio State University,

and Claudio Cioffi-Revilla, Center for Social Complexity, George Mason University.

Although the reviewers listed above provided many constructive comments and suggestions, they were not asked to endorse the content of the report, nor did they see the final draft of the report before its release. The review of this report was overseen by Jonathan D. Moreno, Department of Medical Ethics and Health Policy, University of Pennsylvania Health System. Appointed by the National Academies of Sciences, Engineering, and Medicine, he was responsible for making certain that an independent examination of this report was carried out in accordance with institutional procedures and that all review comments were carefully considered. Responsibility for the final content of this report rests entirely with the author and the institution.

Sallie Keller, *Chair*
Steering Committee for Social and Behavioral
Sciences for National Security Summit

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Introduction

With support from the Office of the Director of National Intelligence (ODNI), the National Academies of Sciences, Engineering, and Medicine has been tasked with conducting an unclassified 2-year survey of the social and behavioral sciences (SBS) to identify promising research opportunities with implications for national security over a 10-year period. This unprecedented task will require considerable input from academics in a range of SBS disciplines and from the intelligence community (see statement of task in Appendix A).

In order to raise awareness and engage these communities in the survey (known here forward as the SBS Decadal Survey), a Summit on Social and Behavioral Sciences for National Security was held October 4–5, 2016, in Washington, DC. Under the auspices of the Board on Behavioral, Cognitive, and Sensory Sciences, a steering committee was appointed to plan and carry out the summit (see Appendix B).

The summit was designed to highlight cutting-edge research and identify future directions for research in a few areas of the social and behavioral sciences. It was organized around a series of presentations in four different themed sessions. These sessions were representative of the research with possible relevance to the work of intelligence analysts but were not intended to be inclusive of all the research the SBS Decadal Survey will consider.

Presenters described what is known in their areas of work and what could be known, as well as identified any current limitations with data or methodology. In addition, representatives from the intelligence community (IC) discussed their understanding of what could be gained by carrying out the SBS Decadal Survey and highlighted recurring issues and long-term

strategic challenges faced by the IC that can be informed by social and behavioral sciences. Each themed session ended with time for discussion and reflection among the presenters, moderators, and IC representatives.

The summit proceeded as follows. Marcia McNutt, the newly appointed president of the National Academy of Sciences, and David Honey, the science and technology (S&T) director at ODNI, delivered opening remarks. An introductory panel with representatives from the Central Intelligence Agency, Defense Intelligence Agency, and National Intelligence Council set the stage for how the SBS Decadal Survey might best inform the work of intelligence analysts. Four themed panel sessions, each moderated by a member of the steering committee, showcased research presentations in the areas of brain and neuroscience, social interaction, behavioral genetics, and risk and decision making. The summit concluded with a session in which Robert Fein, a member of the Intelligence Community Studies Board at the National Academies, offered remarks, and members of the steering committee and representatives from the intelligence community shared final points and reflections. Questions from the audience were encouraged throughout the summit during discussion periods.

A rapporteur prepared the proceedings as a factual summary of what occurred at the summit. The steering committee's role was limited to planning and convening the summit. The views contained in this proceedings are those of individual participants and do not necessarily represent the views of all summit participants, the steering committee, or the National Academies of Sciences, Engineering, and Medicine.

The summit was open to the public and webcast live.¹ These proceedings were created from the presenters' slides, notes, and a full transcript of the proceedings to serve as a public record of the summit presentations and discussions. Presenters were given an opportunity to review and correct the summaries of their remarks.

¹The archived webcast of the summit and available presentations can be found at http://sites.nationalacademies.org/DBASSE/BBCSS/DBASSE_173737 [December 2016].

Opening Remarks

Steering committee chair Sallie Keller (Virginia Polytechnic Institute and State University) opened the summit and welcomed participants and attendees. She emphasized that the day-and-a-half gathering would be a participatory event and encouraged both attendees and virtual participants to contribute to the discussion. She described the summit as a launch event and acknowledged that the presentations at the summit represented a small collection of the cutting-edge research that would be considered in the forthcoming decadal survey of social and behavioral sciences (SBS).

OPENING REMARKS BY MARCIA MCNUTT

Marcia McNutt, president of the National Academy of Sciences (NAS), greeted attendees, thanked them for being part of this endeavor, and provided an overview of the National Academies and the importance of the SBS decadal survey. She noted that the NAS has existed for over 150 years, chartered as an independent organization during the presidency of Abraham Lincoln, and today is part of the National Academies of Sciences, Engineering, and Medicine with a long history of providing advice to institutions, primarily the government, that wish to use science to make good decisions. When the National Academies conduct studies, they engage their elected members and other experts to find scientific solutions to policy, management, and other decisions.¹

¹The National Academies of Sciences, Engineering, and Medicine are private, nonprofit institutions that provide expert advice on some of the most pressing challenges facing the nation and the world. For more information, see <http://nationalacademies.org/about/whowere/index.html> [December 2016].

McNutt recognized that the summit is the first step in a major initiative to identify and prioritize SBS research areas with relevance to national security over the coming decade. She noted that although the National Academies have successfully conducted decadal surveys in areas such as astrophysics and ocean science, this is the first decadal survey in the social and behavioral sciences. McNutt explained that decadal surveys are a way to convene research communities in order to understand what they think are important, cutting-edge, or of high priority.

The SBS Decadal Survey will be entirely unclassified, and she called for broad participation. “We really need to hear both from the science community and from the intelligence community to make this study as strong as it can be and to encourage very wide participation,” she stressed. She applauded David Honey and the Office of the Director of National Intelligence (ODNI) for making the visionary project possible.

OPENING REMARKS BY DAVID HONEY

David Honey (ODNI) reported on the importance of the effort to ODNI. He acknowledged three unique aspects of the project: (1) the first decadal survey sponsored by ODNI; (2) the first decadal survey undertaken in the social and behavioral sciences; and (3) the single biggest project sponsored by ODNI. As such, according to Honey, it represents “a very strong commitment and belief in the need for the study and its value.”

Honey reported that staff at the National Academies asked him what he expected to derive from the survey. He said he recognized the value in bringing together a diverse group of subject matter experts to survey the current state of SBS research, and then to develop a consensus view of worthy R&D objectives to pursue in the future. He pointed to the presenters who followed him on the agenda as his customers, including representatives from the Central Intelligence Agency, Defense Intelligence Agency, and National Intelligence Council. He said he is supporting the project for these and other IC agencies, noting that “ensuring that the intelligence community has an R&D strategy that will deliver the capabilities that our analysts need is a key responsibility of my office.”

Honey explained that the intelligence community is composed of 17 different executive branch agencies and organizations. Some of them, like the Central Intelligence Agency, are their own entities; others, like the Defense Intelligence Agency, are units within larger departments. Each organization has different responsibilities, and some have different legal authorities in what they can do. Legislation passed after 9/11 created the ODNI to provide a formal mechanism for the various parts of the intelligence community to collaborate and, as Honey remarked, to lead inte-

gration of the various strengths across the intelligence community and to deliver information and insight to senior leaders.

Honey noted that IC activities are roughly divided into two categories: collection and analysis. Most people tend to be familiar with collection, since it is often portrayed in movies or in the news. The task of analysis tends to be more of a mystery. Intelligence analysts work on very difficult problems, and the information and insights they provide to government leaders have tremendous ramifications for the country and national security decisions. In carrying out their jobs, according to Honey, analysts use a variety of data sources, tools, and techniques. It is important they make use of the best resources.

ODNI views its role as helping to set priorities for advancing intelligence resources and capabilities. The SBS Decadal Survey is a step toward understanding and articulating future research objectives necessary for improving capabilities, Honey said. He expressed faith in the National Academies' track record in executing this type of project. Honey encouraged attendees to continue to stay involved with the project after the summit, because the SBS decadal survey will benefit from wide-ranging insight and expertise.

Needs of the Intelligence Community

David Honey (Office of the Director of National Intelligence [ODNI]) introduced the first panel of presenters, which included representatives from the intelligence community (IC), who provided insight on how the SBS decadal survey could successfully inform the work of intelligence analysts. They discussed how intelligence agencies use, or would like to use, social and behavioral sciences and what areas might have the most impact on their work.

CENTRAL INTELLIGENCE AGENCY

George Gerliczy (Central Intelligence Agency) noted he has worked with academic experts outside the IC on a variety of projects but is looking for a more comprehensive and consistent interaction to make intelligence analysis stronger. He said the SBS Decadal Survey may make headway against a perennial challenge for IC analysts to stay abreast of the latest findings and advances in the social and behavioral sciences and to draw relevant knowledge into their work.

Gerliczy focused on three messages. First, he highlighted what policy makers, as the customers, expect and need from the IC analysts. Second, he introduced the notion of an analytic framework, which analysts use to make sense of received information and help policy makers understand the issues they face. Third, he suggested ideas for the collaboration between the IC and academics and considered different ways that research can have an impact on intellectual capital building.

Turning to his first point, Gerliczy noted that analysts do three types of tasks. First, they provide policy makers with answers to specific questions. The questions may have been explicitly asked, but more often analysts anticipate and then proactively answer questions. Second, analysts present policy makers with an analytic framework to facilitate the understanding of an issue of interest as well as the processing of new information. As such, the framework has a longer shelf life beyond specific answers to narrower questions. Third, analysts warn policy makers, as appropriate, of impending developments or crises, he said.

Gerliczy noted that the questions policy makers ask analysts vary over time and in terms of specific country, issue, or leader; however, the questions can be categorized in several themes (not an exhaustive list):

- *Strength of leaders and governments*: assessments of the stability or discretion of a particular government or leader and the consequences of a change in leadership;
- *System dynamics*: the risks of failure and instability within a system, whether states, societies, alliances, networks, or organizations, or the kind of system likely to emerge out of a current set of dynamics;
- *Role of political philosophy or ideology*: role of an ideology in motivating political activity or violence, or whether there might be an opportunity for transnational mobilization in support of or against a particular ideology or movement;
- *Calculations between and among states or individual actors*: consideration of a state's or a group's capabilities, plans, or intentions vis-à-vis another state or group, or how a state or group perceives its strategic position in the region or in the world. Questions about deterrence and about action-reaction dynamics also fall into this category; and
- *Identification and measurement of threats*: considerations of threats across a variety of domains, such as political, cyber, terrorist, and military, as well as how, when, and to what end a threat would hurt U.S. interests and the opportunities to undermine or defeat those threats.

Gerliczy next expanded upon his description of an analytic framework. Intelligence analysts, he said, often spend a lot of effort identifying existing frameworks or developing new ones. Frameworks provide insight. An analytic framework is essentially a description of the primary drivers of an issue, that is, the key variables that determine how a situation is likely to evolve. Analysts often have to take the questions asked by policy makers and narrow them to more focused questions where a framework may apply.

For example, if the question is about the stability of a government or leader, analysts might look for a framework that would help identify the factors that determine or reflect newly installed leaders' ability to consolidate power. This analytic framework needs to identify several things: (1) the key drivers or variables that facilitate the consolidation of power; (2) what is known about the interrelationship among those variables and their overall predictive power; and (3) what is known *not to* facilitate the consolidation of power. According to Gerliczy, it is very important to know what research has shown not to matter in order to focus limited resources appropriately. It is also useful to know the leading paradigms for a certain issue, as well as areas of contention or debate (e.g., the gray zones).

Gerliczy pointed out that analysts must be able to apply a framework effectively to a specific context and convey that framework to policy makers along with whatever insights the analysts gleaned from using it. This application takes expertise in two different areas: (1) general, broader understanding of the phenomena (i.e., the issues at play) and (2) specific knowledge of the context or country under consideration.

On his third point, Gerliczy offered suggestions for collaboration between the academic and intelligence communities. Currently, he said, exchanges take place on specific cases (i.e., more narrow applications), but it would be useful to shift to developing frameworks to generate insights with broader, lasting applicability. The challenge is for people outside the IC, including the academic community, to understand what analysts do, what their needs are, and the kinds of assessments they produce. Generally, according to Gerliczy, this is not because of a lack of interest but because of classification restrictions and secrecy and a culture that emphasizes discretion. He suggested the IC become more forthcoming in trying to explain and share its priorities, and he expressed commitment to becoming part of this effort.

Gerliczy acknowledged differences between the way the two communities operate. Often academics, he said, look backward to determine what mattered to a known outcome. The IC looks forward to diagnose a situation as it unfolds and determine implications for policy. There are differences in data, he observed: academics often make use of established datasets or assemble new ones, and the IC typically has either a flood of details or complete lack of information. He also pointed to differences in the two communities' areas of inquiry (areas of narrow focus compared to those with a broader focus or with considerable ambiguity), consumers (fellow experts in a substantive area compared to policy makers, who are generalists), and time frames and space to convey assessments (i.e., often IC analysts are given only a few days and two pages to present their findings).

Gerliczy suggested ideas for overcoming these differences to facilitate collaboration. As part of the SBS Decadal Survey, he offered the CIA's com-

mitment to help academics better understand analysts' priorities and work practices. He said a list of perennial questions will be developed further and prioritized to help those contributing to the project understand what analysts grapple with on a regular basis and where they can use the most assistance.

He also suggested working with the academic community to develop analytic frameworks on pressing problems that could be useful to analysts working in real time. He envisioned a layered analytic framework, such as a 50-page document that comprises a 1-page visual aid (e.g., a graphic or table that frames key factors), 3-page executive summary, and longer literature review. Developing such frameworks would be better if done collaboratively to ensure that the distillation of research knowledge about a particular issue fits the academic community's and the IC's perspectives.

In closing, he noted that success in building broader intellectual capital could have a significant and lasting impact on the quality of analysis within the IC, and thus in enhanced national security.

DEFENSE INTELLIGENCE AGENCY

In his opening remarks, Geoffrey Strayer (Defense Intelligence Agency [DIA]) noted that while DIA may have a narrower analytic focus than the CIA, it performs this analysis for three very large Department of Defense (DOD) customer sets: warfighters, policy makers, and the DOD acquisition community.

Strayer explained that the 2015 National Military Strategy¹ defines national military objectives as follows: deter, deny, and defeat state adversaries; disrupt, degrade, and defeat violent extremist organizations; and strengthen the global network of allies and partners. He emphasized that combat is the last line of defense in everything the military does. However, when it does engage in combat, the military aims to succeed. Strayer pointed out that both staying out of combat and being successful in combat require information.

In managing and analyzing information, the goal is often to be in the position of decision advantage. The DIA uses social and behavioral information to understand adversaries and allies and to gauge their reactions to stimuli. It also uses information and research to understand the implications of behaviors toward military objectives.

The military through the DOD intends to defend U.S. citizens wherever they happen to be. As such, Strayer said, the purview of the department

¹The National Military Strategy of the United States of America, 2015, can be found at http://www.jcs.mil/Portals/36/Documents/Publications/2015_National_Military_Strategy.pdf [January 2017].

spans the globe. Strayer described DOD operations as a large, complex machine with every part requiring intelligence to operate effectively. Intelligence analysis helps determine whether the right goals were selected, and as situations develop and change, it helps determine what will impact the ability to achieve the goals. Globalization, technology diffusion, and demographic shifts can alter the strategic environment. The IC must constantly look for the best information and techniques to build decision advantage.

Strayer suggested areas where additional knowledge would be valuable to military operations:

- *Understanding cultures:* to better know adversaries or allies, especially elements of society engaged in combat. What motivates combat or tensions between factions or between forces in local populations? Who are the role models and icons that drive warfighters' behavior? What rules do they follow in warfare? This is everything from whether they accept collateral damage, their no-strike targets, and their treatment of prisoners.
- *Gauging response and tactics:* to better understand how adversaries or allies will react to military response and changes in weapon systems. Will they be willing to use a dangerous weapon as a first-strike weapon? Or will they consider that weapon as an option only if the United States does a certain activity? What are the tipping points toward peace compared to those toward war?
- *Modifying plans accordingly:* to better ensure success of objectives. Strayer noted that the military prepares for contingencies through an adaptive planning process. The planning process has a number of phases, and each phase is predicated on the success or failure of the phase before. It is critical to know an adversary's culture and tactics in advance of decisions to change plans. What might work as a deterrent for one adversary but not work as a deterrent for another? What might stimulate conflict with different adversaries?
- *Making correct decisions, faster:* to aid decision-making in real time. In modern warfare, the IC is increasingly separated from the decisions made in the field that are predicated on information immediately around the warfighters. Such reality requires planning and preparing for every contingency. Strayer suggested that useful software models would encompass the best understanding of reactions; permit the addition of stimulus to reflect options; take advantage of historical evidence; and allow the testing of possible scenarios before troops are put in danger.

In closing, Strayer emphasized that warfighters need information in a different form than policy makers. Warfighters, who are often put in harm's

way and asked to make decisions, could potentially benefit from knowledge from the social and behavioral sciences.

NATIONAL INTELLIGENCE COUNCIL

Charles Gaukel (National Intelligence Council) explained that his organization is small, resides within ODNI, and draws on senior analytic expertise from across the 17 organizations in the IC. It focuses largely on strategic long-term issues of enduring interest or areas of emerging interest to U.S. policy makers. Gaukel said the SBS Decadal Survey was commencing at a critical time and would help address how the academic experts in the social and behavioral sciences could advance understanding of major challenges in national security and how intelligence analysts can make the most productive use of those advances.

Gaukel concurred with Gerliczy that intelligence analysts are typically charged with anticipating and responding to questions about a particular problem or issue. They are rarely asked to address general questions, whereas the academic community looks at broad explanatory theories with the potential to explain significant portions of variance. Gaukel referred to a book written by the late Alexander George.² The author lamented that much of what scholars focus on is of little interest to national security analysts and policy makers. However, he also pointed out that far too many national security analysts and policy makers have little knowledge of scholarly work that actually might assist them.

George's book identified three areas where more knowledge would be useful: (1) conceptualization of strategies and instruments of policy; (2) limitations and necessary conditions of the successful employment of each of these strategies; and 3) actor-specific behavioral models. These areas remain of interest today, Gaukel said, and are more challenging to understand given the greater dynamism and consequent uncertainty.

Gaukel noted that the potential for strategic surprise is increasing in both pace and diversity. Some areas previously and continuing to be of concern (such as the risk of proliferation of weapons of mass destruction; nonstate actors able to avail themselves of weapons; ideologies that justify extremism and mass terror; and the reemergence of state-on-state war) are being compounded with new concerns (such as social fragmentation and growing inequality; climate change; and cyberattacks that could create global, financial, or social shocks). The IC is only beginning to contemplate the implications of advances in computational science, artificial intelligence,

²George, A.L. (1993). *Bridging the Gap: Theory and Practice in Foreign Policy*. Washington, DC: United States Institute of Peace.

and genetic engineering that may raise profound questions about the very meaning of being human.

According to Gaukel, making headway on intelligence analysis of these concerns is complicated by at least four interrelated trends: (1) the increasing rate of change with which these new challenges, threats, and opportunities emerge, making terms like “over-the-horizon threats” almost obsolete; (2) “noise,” that is, early warnings of emerging threats that are based solely on weak, conflicting, and heretofore unrecognized signals, against a background cacophony of noise; (3) a multiplicity of actors who can directly and quickly impact national security, including states, substates, terrorist groups, and other groups such as nongovernmental organizations, international businesses, and financial firms; and (4) events that unfold in complex closely coupled systems that are often poorly or incompletely understood. Gaukel remarked, “It’s not surprising, therefore, that the intelligence community would reach out to the academic community for help in bounding this uncertainty that policy makers face.”

He said the IC needs help developing and deploying methodologies, approaches, tools, and techniques to understand these concerns and anticipate emerging ones. Gaukel emphasized that advances in methodologies will have to be accessible, understandable, and easily utilized by line analysts. In addition to better tools, the IC needs help determining the quality and utility of data. Without advances in the theoretical understanding of social behavior, increasing access to more and more data may, according to Gaukel, distract analysts, diverting analytic efforts on where data happen to be available instead of on critical factors. Needed subject domains cover a huge spectrum and include, but are not limited to, areas such as understanding deterrence and escalation; implications of massive destruction power; risk of pandemics, either naturally occurring or intentionally caused; and conflict or migration exacerbated or perhaps triggered by climate change.

In closing, Gaukel pointed out that intelligence analysts and policy makers accept uncertainty, but in applying research to practice, analysts need to figure out the tipping point or how to sort out the true positives from the false positives and negatives. He offered an illustration: “It won’t be enough for analysts to be able to tell a policy maker that research shows 70 percent of the time this strategy works. [Analysts need to] accompany that important insight with discussions of the conditions, what intelligence analysts would call indicators, that will enable [considering whether the current context is] located in the 70 percent domain or in the 30 percent domain.”

DISCUSSION

Kent Myers (ODNI) raised the question of whether decision makers would withhold action if they are given information or a prediction that would cause blowback.³ Gerliczy acknowledged that intelligence analysts strive to provide policy makers with a sense of the opportunities and potential pathways along with potential reactions. Policy makers may change their plans if there is an expectation of some type of blowback or they may choose to brace for it. Anytime analysts can help illuminate what is likely to follow from a set of actions or decisions helps policy makers. Strayer added that the DOD wants to support plans with historical evidence and understand any ramifications before it takes particular actions.

In a related question, Margaret Polski (George Mason University) asked how tradeoffs are analyzed and reported. Gaukel pointed out that tradeoffs are more a problem for the policy maker than for the analyst. The role of intelligence analysis is to alert policy makers to potential tradeoffs, at times to areas they might not have thought about. The analysts generally report what they think is happening on a given issue and why, and what they think will happen next. Gerliczy expressed that analysts lay out multiple scenarios and discuss the implications of each one. He agreed with Gaukel that the real tradeoffs are normative with long-term and short-term considerations of the risks and rewards; the IC generally does not engage in weighing tradeoffs because that is a policy maker's purview. Strayer added that the analysts do not always understand what other matters are under consideration and what the policy maker has as tradeoffs.

Valerie Reyna (Cornell University) asked the IC representatives whether their agencies have a formal process for keeping track of when the predictions fail and when they succeed. Gerliczy said the CIA has tried to track outcomes but has been limited in its ability to do so. The vast majority of what analysts provide policy makers cannot be easily framed as a prediction that can be evaluated in terms of success. Ambiguity accompanies how things evolve, and as such, assigning scores to the outcomes has taken tremendous effort. Strayer suggested that developing models that frame steps and potential reactions could be helpful in rethinking how to evaluate analysis work. Gaukel noted that intelligence analysis is not focused on making point predictions. Rather, the important part is giving a policy maker or warfighter a sense of current and potential future events and how the other side might react. He also called attention to the notions of probability and confidence, two related but distinct concepts. The IC tries to review products to make sure analysts are keeping these two notions separate.

³The term "blowback" is used to imply the unintended adverse consequences of a political action or situation.

First Research Session: Brain and Neuroscience

The first research panel was moderated by Valerie Reyna (Cornell University) and showcased cutting-edge work in the area of neuroscience and studies of the brain. Panelists included Paul Glimcher, professor of neural science, economics, and psychology at New York University; Read Montague, professor of physics at Virginia Polytechnic Institute and State University; and Elizabeth Phelps, professor of psychology and neural science at New York University. The panelists presented overviews of their research programs and highlighted key findings, methodologies, data considerations, and relevance to the work of analysts in the intelligence community (IC).

THE KAVLI HUMAN PROJECT

Paul Glimcher focused on the process of data collection as he considered how social and behavioral scientists try to collect sufficient data on the characteristics of individuals for the purposes of making predictions about behaviors. He also considered research gaps and how they might be addressed.

He first introduced the concept of a phenotype, which he defined “as the set of all observable characteristics of an individual that result from the interaction of its genome and its environment.” A set of data on an individual’s genome, environment, and actions provides as complete a description of an individual actor as possible. Generation of phenotypes across a representative population could help characterize an entire population. He argued that limitations in phenotyping are not a problem of technology and analytic capabilities at this point, but more of a failure to collect appropri-

ate phenotyping data. Scientists have access to large datasets, but they end up with very select groups of people who often are not representative of the populations to be characterized. In addition, data are often gathered on people for short periods of time, and as such, the science community lacks sufficient longitudinal information to draw accurate inferences. Glimcher pointed out that well-studied populations tend not to be representative of the nation. For example, a tremendous amount is known about people with certain kinds of diseases. Errors are made when findings from this population are extrapolated back to the national population.

In order to build a database to characterize a general population, Glimcher said three goals need to be achieved: (1) extract a representative sample of people, a perfect cross-section of the community of interest; (2) monitor them for a long time; and (3) collect a wide range of data on them (depth)—for example, their genomes, spending habits, health care, and social networks. Such a project would be expensive (an estimated \$1,500–\$2,000/person). To make it more manageable, according to Glimcher, developers need to reconsider capturing all the data on everyone in a giant cohort and instead think about building a representative phenotypic group from select small cohorts, representative of defined populations. He suggested that models for behaviors of interest be used as starting points to determine what types of individual data should be collected.

Glimcher acknowledged that most people think wide, meaningful phenotyping is impossible, but he remains optimistic about the opportunities. A large body of survey work, illustrated by Glimcher, has shown that longitudinal studies are possible and people are willing to participate for the greater good. Unfortunately, the individual data currently collected in longitudinal surveys¹ are quite narrow and cannot be linked to data in other longitudinal surveys because of the differences in survey samples.

Glimcher introduced the Kavli HUMAN project² as an effort to develop a rapid phenotyping tool and stable platform to capture data at scale and at low cost of representative subpopulations in the United States. Data are to be collected from the first cohort in New York City in 2017 at a cost of about \$12 million. Glimcher noted that members of the public are willing to participate in the project with assurances that their data are maintained for academic use and not given to commercial entities like Google or Amazon or to the government. (The project works with municipal-level government to improve areas like health and education but is insulated from it, he noted.)

¹Examples of continuing longitudinal surveys include the U.S. Health and Retirement Survey, the Fragile Families Survey, and the Longitudinal Dynamics Survey.

²The Kavli HUMAN project has developed over the course of 3.5 years with support from New York University and a large group of national advisers distributed across the U.S. academic and corporate spaces, with the financial support of the Kavli Foundation in Santa Barbara.

Glimcher acknowledged that the future of phenotyping will need to depend on giant databases but not with data from a billion people. He said data can be collected from a much smaller sample to give the insight needed. Accumulating data on 100 million people is only important if the event(s) of interest has a base rate of 1 in a million, he said. Generally, according to Glimcher, that level of precision would not be utilized, and the collection cost would be huge. For most events (rates 1 in 1,000, or 1 in 10,000), samples of 10,000 to 100,000 are more cost-effective and retain the ability to observe events with these base rates.

He emphasized that representativeness is a critical feature of any baseline collection operation. It is often not available, which he said has led to false estimations of base rates on a number of fronts (e.g., health conditions). The problem is that baseline datasets are often gathered based on opportunities. He underscored that datasets need to be designed from the start to be representative. He also pointed out that breadth of data is only powerful if integrated at the individual level with the ability to link assets to characteristics and actions.

In closing, Glimcher noted that the Kavli HUMAN project has developed with the goal of generating new understandings in the civilian and academic world of who people are and how agents operate. The project has created novel recruiting and retention methods to make the study both attractive and affordable to potential subjects. Messages of a public service mission are important in getting people to share their data. Glimcher reported that about 40 percent of New Yorkers expressed willingness to participate in these studies, even though the studies are very invasive and require a lot of work. The project will measure a number of items: traditional medical data, ranging from genome to blood chemistry to real-time electronic medical records; detailed real-time financial data about wealth, labor allocation, and taxes; swipe-level data about consumer purchase behaviors; social network data, such as SMS, MMS, telephone, email, browsing, geotracks, and Bluetooth/MAC addresses of local emitters; education; family interactions; environmental data; and criminal justice experiences. He noted that the ability to track data for adults as well as for children and low-functioning elders has been developed. He viewed the project as “a telescope for humanity” that could serve as a tool to move SBS research forward over the course of the next decade or two.

NEW, NEW NEUROSCIENCE

Read Montague commented on the ambition of the neuroscience community to describe neural function from molecules and cells up through the various parts of cognition that impact the behavior of individuals and of composite groups of people. He acknowledged the ambition is easy to

say but hard to do. There are dynamics at different levels and interactions between these levels.

The field has changed its perspective, according to Montague, from looking outside to looking inside. Previously, the brain was modeled as an engineering system that took streams of information from the outside world and synthesized and reassembled them into what ended up as a perception of behavior. Now, he said, the field is modeling what goes on inside the brain, with the premise that the brain houses its own deep templates of the world. An important shift in scientific thinking, according to Montague, is that the intersection of these templates with the world generates data that the brain responds to. In terms of investigating neural functioning, the old approach relied on modeling starting from outside behaviors. The new approach starts with measurement of brain activity in an agnostic way of stimulating and predicting outward responses.

Montague provided two examples of the new types of scientific investigations. In the first experiment, people (subjects) would be shown a series of evocative visual stimuli from the International Affective Picture Systems database. He illustrated with an image similar to the ones used in the database—a picture of a colleague putting a bunch of worms in his mouth. Subjects are shown pictures for a short period of time and brain activity is recorded using a functional MRI (fMRI). Researchers have found, according to Montague, that an individual's political ideology (as measured by the Wilson-Patterson survey) can be predicted from a record of his or her brain activity on the visual task.³ The research also discovered that the fMRI responses to a subset of the pictures shown (the disgusting ones) were what predicted political orientation (on a conservative end of scale compared to a liberal end of scale). Furthermore, data from asking the subjects to rate pictures consciously were not predictive at all. Montague noted that this shows that the conscious report (behavior) can deviate from what the brain portrays on the current state of fMRI. Research is looking at a subliminal version: that is, what happens if subjects do not even consciously see the pictures if they are flashed for minimal amounts of time.

In the second experiment, an average of 20 people per test group work online at the same time, performing parallel tasks in a market scenario to buy, sell, or hold stocks. The brain activity of three subjects per test group is scanned (about 16 groups tested so far). Montague illustrated that when multiple people perform the task at the same time, bubbles (inflated prices) emerge on various rounds despite a relatively flat mean price. The research

³For more information, see Ahn, W-Y., et al. (2014). Nonpolitical images evoke neural predictors of political ideology. *Current Biology*, 24(22):2693-2699.

found that brain activity in the nucleus accumbens⁴ tracks the bubble of the market in the simulation. Notably, subjects for whom the brain activity predicts their buying behavior tend to do worse in the market scenario than other subjects. Montague suggested that this experiment illustrates situations where what people value is not just a function of themselves, and not even just a function of other people, but also a function of blind mechanisms in the brain and the rules of the marketplace.

EMOTION AND DECISION MAKING

Elizabeth Phelps started her presentation with the recognition that the idea that emotional choices are generally considered irrational and poor, while cognitive choices are considered rational and goal-directed, is a misconception and does not apply to the scientific characterization of decision-making. This view is overly simplistic, according to Phelps, and should be abandoned. Research has shown that the influence (or effect) of emotion on decisions is modulatory; its influence shifts depending on the type of decisions, and the shift can be good or bad depending on circumstance.

Phelps reported that the influence of emotion acts in two specific ways. One is considered integral to the decision process: the emotional reaction to the choice of outcomes becomes incorporated into the value of that choice. This could be a good thing, according to Phelps, as emotion can signal threats in the environment. The second way is considered incidental to the decision process: the emotional response comes from an affective state, such as exuberance, a bad mood, or stress. In general, noted Phelps, it is desired to avoid allowing incidental things unrelated to the choice affect or bias the decision. However, it happens to everyone, such as in making an impulsive purchase.

Phelps focused on the incidental way and the affective state of stress. She defined stress as the body's response to real or implied threat induced by novel, unpredictable, or uncontrollable situations. Science has found that stress has different effects on different parts of the brain. Stress can make parts of the brain—for example, the striatum, the nucleus accumbens, and the amygdala—work better at times. However, even very mild stress can lead to subtle impairments of the function of the prefrontal cortex. Phelps emphasized that acute stress (short periods of stress) and its effects differ from chronic stress (stress that lasts throughout the day or longer periods).

Her laboratory induces acute stress to test its effects. Subjects' hands are placed in freezing water for 3 minutes. This leads to a reliable increase in cortisol in about 20 minutes. This type of stressor has nothing to do with

⁴Reyna pointed out that the nucleus accumbens has been recognized as the reward system in the brain.

subsequent decision tests. Phelps pointed out that “stress is stress”: that is, the neural hormonal changes that occur with stress are rather uniform with different types of stressors.

Phelps illustrated laboratory versions of three types of decisions: (1) attribution, (2) model-based compared to model-free choice, and (3) sequential or foraging. An example of the first decision type is being cut off in traffic. One usually considers the other driver as rude, which is called making a disposition attribution. Social psychologists, according to Phelps, have known about fundamental attribution error for a long time. People tend to make attribution decisions about others whom they do not know well and those not in their social group. In the same situation, if one considers the other driver as rushed, this is called making a situational attribution. Social psychology, noted Phelps, has shown that situational attributions are not the first instinct; they take a little more cognitive control. More recent experiments measuring brain activity continue to confirm this finding, said Phelps. A series of studies in her laboratory found more activity in the prefrontal cortex when subjects look for situational information to make a situational attribution. Her studies also looked at the role acute stress played and found that when subjects were stressed, they were more likely overall to blame a person’s personality in tested situations and less likely to consider the situation or context. Phelps posited that incidental stress biases one to further underestimate the role of situation in defining behavior.

To understand the next decision type, model-based (or free) choice, Phelps explained the difference between laboratory paradigms known as model-free learning and model-based learning. Model-free learning promotes habitual actions without much forethought or attention (done automatically) by linking rewards to context. These types of actions can become insensitive to changes in outcome value or contingencies once they become habits over time. Model-based learning, on the other hand, enables prospective choice of actions and supports adaptation to changes in the environment.

Phelps’s laboratory has developed a two-step task of picking between two images to test the effects of stress on these learning paradigms. In her experiment, the probability that subjects receive a reward after their two selections slowly varies over the course of participation in several trials of the two-step task. If subjects act model-free, they are paying attention to the local context in the task. If subjects act model-based, they are switching based on the transition structure. Phelps notes that this research has discovered that most people follow a combination of both paradigms, with variation in how they use these different types of feedback structures. In this experiment, subjects sometimes performed the two-step task under acute stress. In addition, working memory capacity was also measured for subjects, and it seems to explain some of the differences observed. Phelps reported that

the research found that stress was shifting (or biasing) people to make more model-free choices. However, she said, “this is only true for individuals who on average across [the experiment] group have lower baseline working memory capacity. Individuals with high working memory capacity don’t show this effect.” She concluded that working memory capacity may protect against making more automatic, less goal-directed decision in this case of very mild stress in the laboratory.

For the last type of sequential decisions, Phelps explained that many decisions are made not just one time but repeated until one decides to continue engaging in the line of behavior or switch. The idea of foraging comes from behavioral ecology. Phelps illustrated this with an example of bees drawing nectar from the same flower repeatedly before taking time to move to a new flower as the reward from a current flower decreases. Humans have the same type of continuation decisions, such as in web searches, dating decisions, and jobs.

Phelps defined the optimal switching decision as one where the instantaneous reward rate of staying falls below the average reward rate enough that the cost of time to switch becomes manageable. In her laboratory, a foraging task was simulated by asking subjects to collect as many apples as they could within a fixed amount of time. During a trial, subjects had to decide when it was optimal to use up time to move to another patch of apples. Some of the trials were done under acute stress. Additionally, subjects were asked about their perceived level of stress over the past month as part of the experiment. Phelps reported that the research found that both changes in cortisol to acute stress and subjective perceived stress predicted more of the deviation from optimal switching. Phelps pointed out that humans have learned adaptive behaviors in response to stressors in the environment (e.g., threats to resources); however, when a stressor is completely unrelated to the choice, it is maladaptive. In her laboratory experiments, the unintended consequences influenced by stress were generally considered as negative.

Phelps concluded with several still-unanswered questions, noting that “it’s one thing to identify the relationship between emotion and decision making, another thing to suggest how you change it.” Can resilience to stress be managed to reduce the detrimental effects of incidental stress on decisions? How do the decisions about risk differ in relation to the different types of emotions? Under what conditions might the impact of emotions on decisions be valuable as opposed to detrimental?

DISCUSSION

Charles Gaukel (National Intelligence Council) tried to relate considerations of intelligence analysts to the research presented. He noted that

the issue of representativeness, raised by Glimcher, is very important but perhaps underappreciated by the IC. According to Gaukel, the IC grapples with how to get the attention of policy makers, especially when alerting them to potential emerging risks or opportunities. He said research on effective communications, notably with findings relevant to written communications, would be of value to the IC.

Glimcher noted that academics have worked hard to separate the concepts of risk and ambiguity in the scientific literature. Risk is how people interpret known probabilities of events, and ambiguity applies to situations in which probabilities of occurrence are unknown or partially known. Of note, according to Glimcher, individual traits with regard to risk are not terribly well correlated with the traits regarding ambiguity. He recognized the growing evidence of neurobiological separations between the representations of risk and ambiguity. Adolescents were classically viewed as risk tolerant, but now, with separating the concepts, research finds that adolescents are actually quite risk averse but can tolerate ambiguous situations. Glimcher suggested that adolescents convert their uncertainties to knowledge of risks over the course of adolescence. He added that tolerance for ambiguity tends to decline over one's life span, and negative life events seem to have a significant role in this decline.

Reyna pointed out that the brain continues to develop much later into one's life than was previously thought. She raised the question about what differences age and brain development have on decision-making and what this means, in the same context, for decision makers of different ages.

Margaret Polski (George Mason University) asked the panelists if they have looked at developments in mathematics and statistics in creating synthetic data. Montague said he had used generative models to create data for simple social exchange paradigms of two or three people to look at disease categories or psychopathologies. Polski also inquired how occurrences in the physical environment and social context are considered in studies investigating brain function and behavior. Montague noted that models try to account for some innate behavioral wisdom (i.e., instinctual knowledge of what it takes to be a human being) related to one's physical environment and social context.

Steven Rieber (IARPA) said he saw several challenges in the relevance of large-scale collection of phenotype data to the IC. He said it would be difficult to collect data on populations of interest to the IC because (1) they are non-U.S. people and (2) people of interest tend to be unusual, either in terms of the power they hold or the threat that they pose to the United States. Glimcher clarified that the large-scale phenotyping projects will be noninvasive. The academic community will examine U.S. populations, he noted, to inform health care and other areas of citizen interest. Current research has demonstrated that deep phenotyping is possible, which implies

that phenotyping outside the United States is possible, albeit with both similar and different obstacles.

Jytte Klausen (Brandeis University) noted that her work has focused on behavioral indicators of extreme violence and asked Phelps whether the classification of positive emotions as drivers for action has any relevance. She suggested that perhaps positive emotions are driving this extreme behavior as opposed to what is usually thought of as alienation from society and negative emotions. She then asked about the possibility to create a predictive model for violent extremism given the absence of population markers for anticipating who is more likely to be a violent extremist. Phelps agreed that both positive and negative emotions can drive choices; however, to date, only a crude understanding of the influence of emotions is known. It is harder to generate a positive effect than negative effect in the laboratory, according to Phelps, so the former is probably underinvestigated. She noted that research is just starting to break down affect into different components and look at specific decision processes to uncover how different affect factors, like stress, mood, physiological arousal, and subjective states, come together to influence a choice. On the second question, Phelps explained that it would be very hard to identify indicators of violent extremism without a lot of data from larger populations, looking at individual variability across life span and social and emotional environments.

Glimcher pointed out that a tremendous amount of data can be collected on a known bad actor; however, understanding how that bad actor differs from all the other actors is what is important. The challenge is having a good understanding of all the things necessary across a population to determine which variables are independent and which variables are highly correlated with violent behavior.

Jacqueline Wilson (Civic Fusion International) asked Phelps about any differences on decision-making for those with trauma and longer-term stress. She also asked whether perceptions of risk are different if threats are made through social media or hate speech, as opposed to physical threats. Phelps acknowledged a few findings from the large amount of literature on chronic stress. Chronic stress leads to large changes in the brain and problems with memory. More chronic stress in one's lifetime increases one's responsivity. Chronic stress is not the same as acute stress. Phelps underscored that mild acute stress is quite common, and even this mild stress can have an effect on decisions.

Bear Braumoeller (The Ohio State University) pointed to a movement in political science in recent years toward techniques that are more robust to the existence of unmodeled confounders and asked about parallel work in other disciplines. Glimcher recognized the importance of solving the problem of stratifying the variables known to be influential. The challenge, he said, is the covariance structure. If all the variables were independent,

very little data would be needed and the dataset could be modeled, but this is not the case. He emphasized that creating large representative datasets will help identify the covariances. An infinitely large dataset can never be achieved, but he reminded the audience that small representative datasets can be useful and need to be assembled. The good news, according to Glimcher, is that the analytic capabilities exist.

Second Research Session: Social Interaction

The second research panel was moderated by Thomas Fingar (Stanford University) and showcased cutting-edge work in the area of social interaction. Panelists included Joshua Epstein, professor of emergency medicine at Johns Hopkins University; Susan Fiske, professor of psychology and public affairs at Princeton University; and Mathew Burrows, director of the Atlantic Council’s Strategic Foresight Initiative. Panelists presented overviews of their research programs and highlighted key findings, methodologies, data considerations, and relevance to the work of analysts in the intelligence community (IC).

AGENT_ZERO AND GENERATIVE SOCIAL SCIENCE

Joshua M. Epstein discussed agent-based computational modeling in the social and behavioral sciences (SBS) and, in particular, the use of artificial societies composed of interacting software individuals. He based his address on his most recent book, *Agent_Zero: Toward Neurocognitive Foundations for Generative Social Science*.¹ According to Epstein, “*Agent_Zero* is meant to be a neurocognitively grounded agent, capable of generating a wide range of important phenomena, including collective violence, financial panic, endogenous networks, [and other] collective be-

¹Epstein, J.M. (2013). *Agent_Zero: Toward Neurocognitive Foundations for Generative Social Science*. Princeton, NJ: Princeton University Press. This volume is the third in a trilogy of books on agent-based computational modeling, all of which have advanced the generative explanation of macroscopic social regularities.

havior.” He noted that *Agent_Zero* is designed to be a mathematical and computational alternative to the “rational actor.”²

With generative modeling, according to Epstein, the idea is to explain social regularities, such as wealth distribution, disease dynamics, settlement patterns, or segregation, by “growing them” in artificial societies on timescales of interest to humans. In other words, the macroscopic patterns emerge from agent interactions at the micro level. Epstein reported that *Agent_Zero* is different from other mathematical modeling because it tries to encompass emotional dynamics and cognitive plausibility. Specifically, agents in the model are endowed with distinct affective, deliberative, and social modules grounded in neuroscience. These internal modules interact to produce individual behavior that may be far from rational. The interactions of multiple agents of this new type generate a wide variety of collective dynamics, such as violent mass behaviors. In this model, Epstein noted that the minimum characterization for cognitive plausibility includes emotions, bounded deliberation, and (endogenous) social connection.³

Epstein pointed out that the idea of the book was to start a synthesis; the components in the model are all provisional and can be improved and extended.

Epstein provided an example of how the model might be used as a conflict interpretation. Figure 5-1 depicts three *Agent_Zero*-type individuals (in blue). He said they could be considered mobile soldiers occupying a landscape of indigenous sites (yellow). The latter are not of the *Agent_Zero* type but are simply passive (stay yellow) or actively aggressive (turning orange at some stochastic rate). In response to the indigenous sites, there is a binary retaliatory action that occupying agents can take: destroy all indigenous sites (indiscriminately) within some radius (destroyed sites become dark red). Taking or not taking the retaliatory action depends on the affective, deliberative, and social forces operating inside the occupying (*Agent_Zero*) agents.

²The so-called rational actor model has dominated mathematical social science since the work of John Nash: Nash, J. (1951). Non-cooperative games. *Annals of Mathematics*, 54(2):286-295.

³The model follows explicit mathematical equations. The affective module is a generalization of the classical Rescorla-Wagner (1972) learning algorithm [Rescorla, R.A., and Wagner, A.R. (1972). A theory of Pavlovian conditioning: Variations in the effectiveness of reinforcement and nonreinforcement. In A.H. Black and W.F. Prokasy (Eds.), *Classical Conditioning II: Current Research and Theory* (pp. 64-99). New York: Appleton-Century-Crofts.] The deliberative module computes a moving average of local relative frequencies over a memory window. The social component—the inter-agent weights—are based on a strength-scaled affective homophily. Epstein has developed both differential equation and agent-based computational versions of *Agent_Zero*. To ensure complete replicability, all code and all assumptions for all runs are explicitly provided in the book or on its Princeton University Press website.

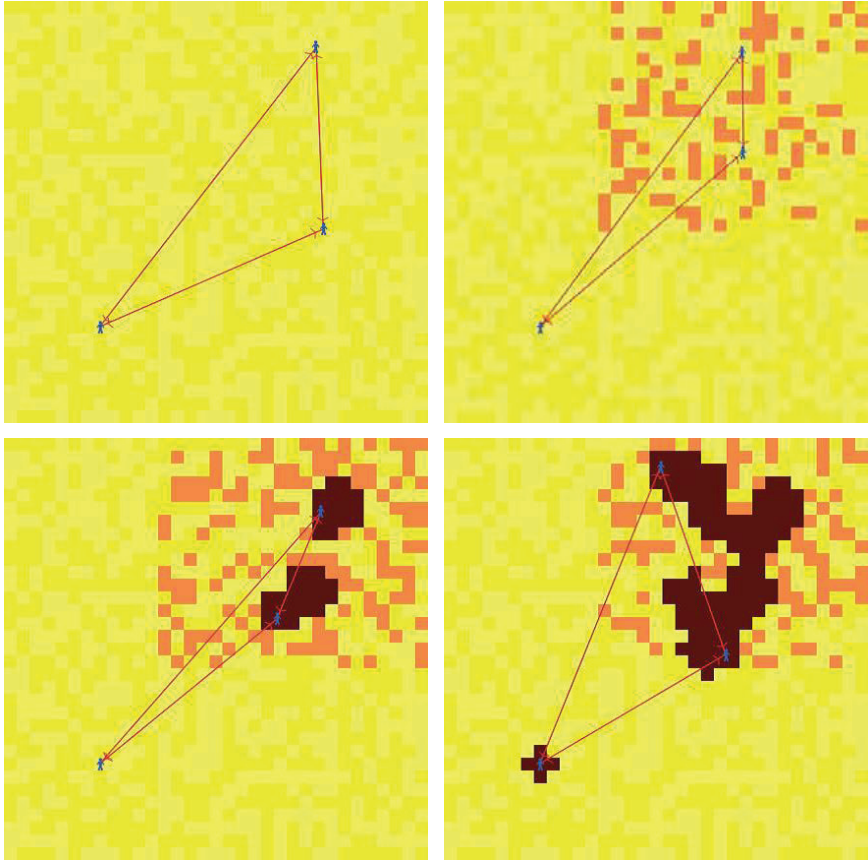


FIGURE 5-1 Conflict interpretation in agent-based computational modeling.
 NOTE: *Agent_Zero* fixed in southwest with zero direct stimuli. Others in northeast experience violent action stimulus. By dispositional contagion, *Agent_Zero* acts.
 SOURCE: Epstein, J.M. (2013). *Agent_Zero: Toward Neurocognitive Foundations for Generative Social Science*. Princeton, NJ: Princeton University Press. Reprinted with permission.

According to Epstein, their “affect is constructed in this model by having agents fear condition [modeled classically] on local aversive stimuli. The bounded rationality [i.e., deliberative] component is [represented by having them] take the local relative frequency of ‘bad’ actors over total actors within their sensory radius, or ‘vision.’ The sum of those is called the [agent’s] *solo disposition*.” But, Epstein continued, the other occupiers also have solo dispositions that weigh on the agent. This weighted (social) sum is

the agent's total disposition to retaliate. He explained that if and when the total disposition exceeds the individual's threshold, that agent takes action.

Of central interest to Epstein is the case where an agent *not* subject to any aversive stimulus nonetheless destroys innocent sites. As shown in Figure 5-1, Epstein studies this by fixing one occupying agent in position in the (nonviolent) southwest with all aggression (orange explosive sites) taking place in the northeast, far beyond the fixed agent's vision. However, occupying agents in the northeastern region do experience attack and fear-condition on these violent stimuli. Epstein reported, "They're also computing a relative frequency of [bad actors] within their vision to get an empirical estimate of [enemy prevalence] in their neighborhood. And when the sum of those exceeds their threshold, they wipe out sites. And because they are connected to [the fixed] agent [through inter-agent weights], he also wipes out sites despite never having any aversive experience at all." The mechanism, moreover, is not imitation of observed behavior, but rather what Epstein dubs "dispositional contagion."⁴

Even more arresting was Epstein's later example of an agent who is subject to no attacks, but who nonetheless *leads* the retaliation. The agent ends up as the first to destroy sites because of dispositional contagion, whereas left to his own devices, he would not have attacked at all, said Epstein. Epstein pointed out that the important feature of the mathematical equation guiding the simulation is dispositional contagion, not imitation of overt behavior: that is, no agent's binary action appears in the governing equation.

Epstein reviewed some neurocognitive underpinnings of the model, emphasizing fear through activation of the amygdala. This machinery is considered to be innate, automatic, fast, and inaccessible to deliberation. He noted that humans have the capacity to fear condition on what would otherwise not be salient (noticeable) stimuli. He pointed out that there are simple ways to create fear conditioning: for example, exposing one repeatedly to a stimulus (a blue light, for example), which is immediately followed by a shock or other painful experience. One begins to fear the appearance of the (painless) blue light. Epstein noted that fear conditioning is emulated in the model as agents associate particular indigenous sites with an adverse stimulus, such as an ambush. The binary act (retaliation) then mimics an automatic neural process and an unreflective response.

Epstein pointed to the literature on the social transmission of fear without direct stimulus as the basis for modeling fear as contagious. He also noted that when agents in the model take action based on the local

⁴The webcast of Epstein's presentation, including an animation of the "Slaughter of Innocents" scenario discussed here, can be found at http://sites.nationalacademies.org/DBASSE/BBCSS/DBASSE_173737 [January 2017].

relative frequency of bad actors, they are emulating two well-documented cognitive errors (reliance on the representativeness heuristic and base rate neglect). In addition, the model is built, according to Epstein, on the neuroscience of social rejection and attendant conformist pressures. In the model, conformist pressures (to avoid the pain of rejection) produce widespread convergence on counterproductive behavior (i.e., the alignment of affect produces connection and strengthens it).

He illustrated several published extensions of the model, including actions to flee (rather than destroy) an adverse situation, noting the relevance of this to refugee dynamics.⁵ There are also instances of corrupt regimes and citizens' reactions, as well as jury trials and collective decisions, each with different sets of binary actions. These include model runs where no jury agent would convict on its own, but they unanimously do so under dispositional contagion. Epstein called this a case of "universal self-betrayal."

Epstein concluded his presentation by reiterating that the *Agent_Zero* model should be deepened, scaled up, and calibrated with real data. His goal is a neurocognitively grounded formal model capable of generating important social phenomena, to serve as an explicit functional alternative to the rational actor and as a foundation for generative social science.

STEREOTYPING AND NATIONAL SECURITY

Susan Fiske reviewed evidence that simple principles of stereotyping are correlated with national inequality and also with a national peace conflict index. She reported that stereotypes operate on two dimensions that appear to be universal across the several dozen societies that her research program has studied: these dimensions are warmth (trustworthy, friendly) and competence (capable, effective). According to Fiske, the combinations of these two dimensions go beyond the notion of just simple good/bad stereotypes; that is, a group stereotype might be high or low on both dimensions or might be high on just one and low on the other. The latter combinations (high warmth/low competence or low warmth/high competence) are considered ambivalent combinations of stereotypes, and according to Fiske, they can be crucial for distinguishing countries. Fiske explained that societal variables predict this ambivalence.

Fiske defined the dimensions that are needed to be known about an unknown individual or group. First, are they friendly (warmth dimension) or are they antagonistic? Second, are they able to act on their intentions

⁵Extensions of the model can be found in Epstein, J.M. (2013). *Agent_Zero: Toward Neurocognitive Foundations for Generative Social Science*. Princeton, NJ: Princeton University Press.

(competent) or not? Fiske has collected cross-national data⁶ from dozens of countries and found that poor people all over the world (e.g., refugees, asylum seekers, homeless people, and immigrants) fall into the low/low quadrant, viewed as low on warmth and low on competence. Notably, in her research, people report feeling disgust and contempt toward these people. In contrast, a society's particular reference groups tend to fall in the high/high quadrant; in most countries, according to Fiske, this reference group includes that country's citizens and middle-class people.

Across societies, Fiske reports that groups seen as well-intentioned but incompetent include older people and people with disabilities, and groups seen as highly competent but cold include rich people and elite professionals. She provided an example from U.S. data: using the group as the unit of analysis, the researchers subjected the data to cluster analysis and plotted the means in a high warmth/low warmth and high competence/low competence 2x2 grid. For U.S. data, stereotypes of middle-class people, blue-collar workers, Christians, and white people fall in the high/high quadrant; stereotypes of poor people and teenagers fall in the low/low quadrant; stereotypes of children and old people fall in the high warmth/low competence quadrant; and stereotypes of rich people and to some extent Asian and Jewish people fall in the low warmth/high competence quadrant. Fiske pointed to groups clustered in the middle, neutral space (black people, conservatives, atheists, and Muslims), noting that stereotypes for these groups differentiate by subtypes within the groups.

Fiske reported that early in her group's research, samples produced a fair amount of ambivalent combinations, and no correlation appeared between warmth and competence. Beginning with samples from Switzerland, a high warmth/competence correlation emerged. In this case, there were less ambivalent combinations, and Fiske and her colleagues credited this to Switzerland's "big social safety net" to support a more inclusive ingroup (all citizens including unemployed people and people with disabilities) but still some extreme outgroups (e.g., asylum seekers). Scandinavian countries show a similar pattern of positive "us" and a few negative "them." In contrast, other countries (such as South Africa, Mexico, and the United States) show more ambivalent stereotypes. Eventually, the research was extended to Middle Eastern countries with high conflict, where interesting patterns of low ambivalence stereotypes were observed.

Fiske reported the research, then looked at macro-level variables such

⁶The standard method of collecting data in Fiske's research program is to have a sample of about 30 to 50 adults nominate their society's groups. In the second phase, a larger sample rates 16 to 30 groups. Because there is considerable consensus, noted Fiske, only 60 to 100 adults need to be surveyed to provide a stable estimate of ratings on groups. The group becomes the unit of analysis.

as the Gini coefficient of income inequality, gross domestic product (GDP), the total number of groups in the society, and power distance. She and her colleagues found that the warmth/competence correlation correlates with the Gini coefficient but is not moderated by the other variables. That is, she explained, inequality predicts more ambivalence, as if those nations have more to explain. The research uncovered a pattern, according to Fiske, that countries with more moderate peace-conflict showed more ambivalence in stereotypes, but extremely peaceful and extremely conflictual countries both show less ambivalence in stereotypes.

In closing, Fiske noted that the content of stereotypes fits with an overall causal model to guide future research—a model in which social structure, competition, and status between groups in a society predict these images of warmth and competence, which in turn predict emotions toward groups, which in turn are the precursors to behavior.

CHANGING TRENDS FOR A FUTURE WORLD

Mathew Burrows reflected on the differences between the kinds of issues considered today compared with those considered or anticipated in the past. Burrows reported that from the 1990s into the beginning of the 21st century, four key assumptions seemed to be backed by data and societal trends. He pointed out that those assumptions have changed in the past 5 or 6 years.

According to Burrows, the first assumption considered that as part of integration or globalization, rising states would join the western order, largely because of the benefits that could be derived from doing so. The second assumption was the belief that there would be ideologies or differences of opinion, but not on the same scale that existed before the end of the communism-against-capitalism era. The third assumption took a positive economic outlook and considered that the vast majority of technological changes would be very positive and increase productivity. The fourth assumption was the belief that conflicts would die down.

Burrows referenced a paper on global inequality that points out that middle classes in the West have not kept up in terms of income increases.⁷ Globally, the proportion of middle-class consumption is increasingly situated in the East and the South. He noted an increase in educational attainment worldwide and a closing of the gender gap, with more young girls having the same opportunities as young boys.

⁷Khara, H., and Gertz, G. (2010). The new global middle class: A cross-over from west to east. In L. Cheng (Ed.), *China's Emerging Middle Class: Beyond Economic Transformation*. Washington, DC: Brookings Institution Press. Available at https://www.brookings.edu/wp-content/uploads/2016/06/03_china_middle_class_kharas.pdf [January 2017].

The aging of societies, according to Burrows, was not even considered 20 to 30 years ago, but is now a big concern as spending on pensions and health care goes up. In the United States, health care costs are a much higher percentage of GDP (18 percent) than in other industrialized countries (10 percent). Burrows said this issue could affect national security as discretionary spending in federal budgets decreases. He presented information and statistics to show that the growing labor pool and productivity was responsible for economic growth in the 1950s through 1970s, but today U.S. economic growth is being challenged because of an aging population.

On the notion of ideologies, Burrows pointed out that the growth in democratic societies is plateauing. He also noted that the degree of attraction of jihadism within populations in Western societies, although not a predominant threat, was surprising. On technology developments, according to Burrows, concerns about the costs of cybersecurity have begun to outweigh expectations of productivity gains from emerging technologies.

In terms of conflicts, Burrows recognized that the nature of conflicts has changed but not disappeared. Notably, intrastate conflicts have increased. These types of conflicts often last 6 to 9 years and are very difficult to end with durable peace. Additionally, Burrows reported on the concern about the reemergence of state-on-state conflicts.

In closing, he identified the likeliness of four possible states of the world. He thought a “reinvigorated West” and a “new global concert” were the least likely conditions to emerge. He thought a “breakdown into blocs” was most likely with evidence to the increasing trade within regions and ongoing talk about the fragmentation of the Internet. The “new bipolar cold war” is also a possibility looking over a 10- to 20-year time frame, according to Burrows, which would position Russia, China, and others against the United States and its partners.

DISCUSSION

George Gerliczy (Central Intelligence Agency) offered comments from his perspective in the IC. He observed that the IC has a growing interest in a broader set of societal issues. Traditionally, the IC developed around specific threats focused on the leadership and military capabilities in specific countries. Gerliczy noted increasing focus on leaderless movements and societal issues along the lines of contagion, collective action, and diffusion.

Gerliczy’s second observation related to formal models. He noted the bar is high for using models, particularly if they are not sufficiently transparent. Their use requires buy-in from fellow intelligence analysts and the ultimate customers or policy makers. He said he has had positive and negative experiences with models. In the situations where a model worked well, according to Gerliczy, the analysts (and sometimes policy makers) could ask

questions of the model developer on the track record of the model, how the model is calibrated, and whether applying the model to a new situation is interpolating or extrapolating. Ultimately, Gerliczy noted, the model must prove valuable in terms of the practical insights generated.

Valerie Reyna (Cornell University) asked the panelists to consider how a model that described what currently existed might adapt to changing social conditions. For example, in a model of social structure and outcomes, increasing the education of women would change the social structure in some societies, which could change the images, which could change the emotion, and therefore change the outcomes. Fiske responded that her research program has another model about gender bias, which is predicated on ambivalence. In many societies, traditional women are seen as warm but not competent, and nontraditional women are seen as competent but cold. Additionally, she has found that an individual difference measure of people's beliefs in hostile or benevolent sexism correlates with United Nations indices of gender development.

Mitzi Wertheim (Naval Postgraduate School) pointed out the need to understand different cultures better and to learn from work in the field of anthropology. She referenced a book by Jim Clifton, *The Coming Jobs War*, which called attention to the global problem of large populations of young men without job prospects.⁸

Fiske asked Burrows whether an inflow of young immigrants who work and contribute to Social Security, but do not draw on it, can offset some decline in economic growth. Burrows reported that in a study conducted in Germany, modeling showed delay on the impact of the aging population by about a decade if Syrian and other immigrants were integrated successfully and performed at the same productivity levels as German workers. He said he recognized that this raises an important point in how discussions about immigration are framed and integrated with other issues.

Irene Wu (Federal Communications Commission) asked Epstein whether the *Agent_Zero* model can be used to understand someone who is not committing violence but instead trying to organize communities. She noted cases where people unconnected with certain events are able to collectively organize a protest or movement through social media. Epstein agreed his model could apply to this scenario. He explained that the self-organization of groups identifying with one another is the mechanism of network formation in the model and, furthermore, that his work is interested in both the construction and dissolution of networks. He also commented on resilience. A single bullet, he said, might stop a bear, but does not work against a bee swarm because the swarm reconstitutes itself and is resilient to local disruption. He suggested that in situations of extremist

⁸Clifton, J. (2011). *The Coming Jobs War*. New York: Gallup Press.

network formation, perhaps a strategy for dissolution would be to enable a decentralized immune reaction.

Epstein suggested that there was no escaping modeling, even for people who are skeptical of models. People naturally have mental models, he said, even if they are implicit models where the assumptions are not made clear. He also pointed out the difference between explanatory and predictive models. For example, plate tectonics explains earthquakes but cannot predict them. Epstein said, “A lot of social science is about identifying the fundamental drivers of social dynamics, even if . . . what will happen tomorrow [cannot be] predicted. These drivers could [help] detect signatures of instability. . . .”

Gerliczy responded with a caveat that some intelligence analysts associate models with things that are high cost and low payoff. Sometimes it has to do with implementation of models in the past, he commented. Fingar pointed out that far too much information is collected, and irrelevant data are often analyzed. He suggested that models be used to consider which data should be examined.

Third Research Session: Behavioral Genetics

The third research panel was moderated by Steven Hyman (Harvard University) and showcased cutting-edge work in the area of behavioral genetics. Panelists included Benjamin Neale, assistant professor in medicine at Harvard Medical School, and David Cesarini, associate professor in economics at New York University. Each panelist presented an overview of his research program and highlighted key findings, methodologies, data considerations, and relevance to the work of analysts in the intelligence community (IC).

Hyman said a discussion on behavioral genetics is worthwhile to acknowledge the rapidly accelerating research advances in the field and closely look at claims and possibilities. “Genetics gives clues to biology,” he said. If a trait is at least partly heritable, whether a physical characteristic, an illness, or a behavioral variation, then markers for traits of interest can be found in DNA variations. These provide tools for biological investigation and stratification of human subjects for study. DNA is already widely used in forensic science and for genealogy to identify people’s relations to other individuals and among diverse human populations.

Hyman pointed out that the nucleus of human cells has 3 billion base pairs of DNA that make up a human genome. DNA makes messenger RNAs, which are turned into proteins that are the building blocks of cells. According to Hyman, it is understood that differences in proteins encoded by variations in DNA sequence influence behavioral tendencies through the ways that brains develop, process information, and change as one grows and learns. Hyman emphasized up front that DNA is not a deterministic blueprint of behaviors. Its influences are exerted in the context of diverse

environmental signals, and there is a certain amount of stochasticity or noise in the reading out of DNA during development and in response to the environment throughout life.

Physical characteristics (e.g., adult height and body mass index), normal behavioral tendencies, cognitive ability, and many diseases and behavioral disorders are highly influenced by genes.¹ These traits are the manifestation of many slight differences in the DNA sequences of people's genomes. Hyman noted that a very small number of genetic illnesses are caused by a single highly penetrant gene. Huntington's disease is one of those; people with the Huntington's risk gene will get the disease if they live long enough. Most other diseases are much more complex, as is all normal behavioral variation, resulting from an aggregate of variations in many genes that appear to contribute small individual effects. There is no single gene responsible for them (schizophrenia, for example). Rather, according to Hyman, hundreds of loci in the genome can influence such traits.

Hyman recognized that identifying the many signals of very small effect has been difficult because they must be discovered against a huge background of neutral human variation. However, advances in technologies have created a genetic revolution; gene chips now allow scientists to determine a person's genotype (DNA sequence) at a million or more places in the genome very cheaply, and the cost of sequencing DNA has come down significantly,² making it feasible to study the entire genomes of many individuals. According to Hyman, as more and more DNA samples are analyzed and convergent information about genetic variance accumulates, scientists are expanding their understanding of disease mechanisms, including disorders of cognition and behavior, but also biological contributors to many normal physical and behavioral traits. Predicting the occurrence of a disorder or some behavioral trait is probabilistic. However, Hyman noted that when combined with other sources of information, prediction, although still probabilistic, gains in power.

BEHAVIORAL GENETICS AND POLYGENIC INHERITANCE

Benjamin Neale summarized the state of the field of genetics in understanding certain kinds of behavior. He reviewed the idea of polygenic inheritance in order to bound enthusiasm on what can be predicted. Science and medicine have known of a biological basis for physical traits and

¹Hyman pointed out that autism, schizophrenia, and bipolar disorder are highly heritable.

²The cost of sequencing DNA has decreased faster than Moore's law for microprocessors. Moore's law, named after Intel cofounder Gordon Moore, predicts that the number of transistors per square inch on integrated circuits will continue to double each year.

disease within families (heritability) for a long time but have not figured out the mechanisms driving these traits.

According to Neale, “in the last 15 years, [science has advanced to] mapping of the human genome outright, characterization of genetic variation in populations, in particular the single nucleotide polymorphisms, the single base pair changes, and the correlation across those different genetic variants . . . to genome-wide association arrays.” Neale pointed out that these arrays allow scientists the opportunity to study genetic variation on hundreds of thousands of individuals simultaneously.

Neale further noted that many of the 18,000 to 20,000 genes in the human genome are involved in a variety of different disorders. Specific genes have been found to be involved in multiple different diseases that are related. For example, the same types of genes that are markers for Crohn’s disease are also markers for rheumatoid arthritis. Neale acknowledged that growing awareness that genes influence multiple things has changed how scientists think about prediction of traits.

He provided an example of investigating schizophrenia. Schizophrenia is a behavioral phenotype because it is diagnosed based on psychiatric interview and includes symptoms like hallucinations, excess paranoia, and disorganized thought. Neale reported that genetic studies have looked at whether certain gene variants are more common in cases with schizophrenia than in control samples without schizophrenia. These studies have moved toward large-scale investigations of genome-wide associations on schizophrenia. One of the first large studies had sample sizes of 2,600 cases and 3,300 controls; however, noted Neale, the evidence was not strong enough to be sure that certain variants were associated with schizophrenia.

To make headway on suspected associations, according to Neale, the research community working on schizophrenia genetics formed the Psychiatric Genomics Consortium (PGC) to share data. Through the consortium, sample sizes for studies were tripled, and scientists became confident they had sufficient evidence to identify five genome-wide regions where genetic variant was influencing the occurrence of schizophrenia. As cases and data have been added, samples have reached over 25,000 cases (with 28,000+ controls), and scientists have identified about 100 to 150 genome-wide significant loci for schizophrenia. While these discoveries are exciting, Neale reported that the science is far from interpreting whether these signals are the biological mechanisms for schizophrenia. However, the signals do help scientists decide where in the genome to invest their time.

In terms of figuring out how much risk for schizophrenia these genetic variants confer, Neale reported that “typical risk estimates for these kinds of effects range in odds ratios of 1.05 to maybe 1.2, which is a very small perturbation in risk when . . . a baseline rate for schizophrenia [is only] 1 percent [of the population].” However, it may be possible, Neale suggested,

to create a tailored score (a polygenic risk score) for an individual, summing up the effect sizes of the genetic variation across his or her genome. The degree of prediction, according to Neale, is improving but remains low at this time. Studies developing polygenic risk scores have found that individuals who would score in the top 10 percent in polygenic risk score have an absolute risk of getting schizophrenia of around 3 percent, compared with the 1 percent observed in the overall population.

Neale said prediction could improve if tools can be combined. For example, risk-factor inventories have been useful for some time. One for predicting the risk of coronary heart disease is the Framingham Risk Score, recently updated by the American College of Cardiology, which creates a score based on a combination of behaviors and characteristics like smoking, LDL cholesterol, HDL cholesterol, diabetes, hypertension, whether treated, and age. Current research is creating an index to increase prediction potential by reviewing genetic risk in conjunction with information from the Framingham Risk Score or the American College of Cardiology Risk Score.

Neale stated that all behavioral traits have some genetic basis, and combining genetic and phenotypic information will help build better predictors. Genetic prediction continues to improve as sample sizes increase and polygenic risk scores are created. He cautioned that taking a purely genetic deterministic point of view is not an accurate reflection of the current science; genetic information needs to be considered with phenotypic information. Prediction is still challenging, especially with rare events.

PREDICTING BEHAVIORAL TRAITS FROM GENOMIC DATA

David Cesarini expanded on Neale's presentation about predicting outcomes from genotypic data, but focused on behavioral traits. He began with background on the kind of evidence available before the explosion of genomic data. Earlier genetic studies compared outcomes among twins and adoptees. Cesarini pointed out that, with the steadily increasing technological advances and dramatic falls in the cost of measuring DNA, progress in the field of behavioral genetics has been quite rapid.

He referenced a study of Swedish brothers, born between 1950 and 1970, which looked at sibling correlation for five different outcomes: (1) height, (2) body mass index (BMI), (3) years of schooling, (4) cognitive skills as measured by a test like the Arms Force Qualifying Test, and (5) socio-emotional skills from a military psychologist's assessment of their ability to deal with wartime stress. Correlations on these outcomes among siblings were considered on seven different sibling types (in declining "genetic relatedness" order): (1) monozygotic twins, (2) dizygotic twins, (3) full siblings living together, (4) full siblings living apart, (5) half siblings

living together, (6) half siblings living apart, and (7) adoptees. Cesarini presented a graph illustrating that as the degree of genetic relatedness declines among different types of siblings, the observed amount of similarity declines.

Cesarini pointed out that the focus of behavioral genetics is also about looking for correlations to make inferences about heritability.³ The term “gene discovery,” according to Cesarini, refers to a process of considering an outcome of interest and identifying genetic variants that are statistically distinguishable among people with different genotypes.

Cesarini reviewed how gene discovery studies have changed. Historically, the most common research approach has been what is known as a candidate-gene study. The candidate-gene studies would test hypotheses of biological function for particular genetic variants (i.e., a small set of SNPs⁴) on specific outcomes. According to Cesarini, these studies have found some associations between gene variants and outcomes; however, they have not been easily replicated for a number of reasons. Cesarini identified some concerns with this methodology: (1) the hypotheses may have some face value but not the biological underpinning; (2) small sample sizes do not afford enough statistical power to draw strong conclusions; (3) the methodology does not deal effectively with confounding variables; and (4) there was a lot of undisclosed hypothesis testing in the field that made studies difficult to interpret and replicate.

A different and emerging research approach to gene discovery, noted Cesarini, is what is known as a genome-wide association study (GWAS). Used in the schizophrenia studies presented by Neale, this approach consists of atheoretically testing a large number of genetic variants for association with some outcome. Cesarini pointed out three advantages of GWAS: (1) an up-front understanding that the methodology is testing about 1 million independent hypotheses; (2) genome-wide data help deal with confounding variables and ensure that analyses are conducted in a genetically homogeneous sample; and (3) it follows from the logic of Bayes’ rule. Results from GWAS research have helped scientists, according to Cesarini, understand why the link to heritability is indiscernible; that is, the effect sizes have been “hiding” across a number of genetic variants. He noted that the GWAS literature is still in its infancy, but the method shows promise for studying many personal traits.

Cesarini summarized the current state of GWAS findings for three

³ Cesarini referred to heritability as an R squared from a regression of outcome on all kinds of genetic variables, which indicates its predictive power on the outcomes.

⁴ SNPs (pronounced as “snips”) stand for Single Nucleotide Polymorphisms. A SNP is the replacement of a nucleotide (a DNA building block) in a DNA segment and the most common form of genetic variation among people. For more information, see <https://ghr.nlm.nih.gov/primer/genomicresearch/snp> [December 2016].

traits: height, BMI, and years of education. He pointed out that like the work with schizophrenia, “as the discovery samples get bigger and bigger, the number of independent variants that reach genome-wide significance increases.” Cesarini reported that the science has currently identified over 700 independent loci at genome-wide significance associated with height; about 100 associated with BMI; and about 160 associated with years of education. In addition, the replication record is quite encouraging. However, noted Cesarini, the predictive power is quite small. Currently, about 14 percent of variation in height and about 7 percent of variation in BMI and education can be explained by genetic data. If sample sizes were quadrupled (about 2 million people), Cesarini suggested that a quarter of the variation in height and maybe 10 to 12 percent of the variation in BMI and education could be explained by genetic data. He pointed out that these figures are not huge but are also not negligible. He estimated that this future predictive power on height from genetic information would be roughly the same as the predictive power from knowing the average height of two parents.

According to Cesarini, in the shift in how gene studies are conducted, scientists have learned that candidate-gene studies with small samples have a weak replication track record; the replication track record of GWAS research is a lot stronger; and the number of associations identified and the predictive power of scores increase as the sample sizes have increased. Cesarini remarked that the GWAS work has illuminated the principle of polygenicity: that is, human traits are associated with very many genetic variants, each one accounting for a small percentage of the observed variability.

In closing, Cesarini noted that the field of behavioral genetics will expand the number of phenotypes for which predictions become feasible beyond the three traits illustrated in his presentation. He suggested that gene discovery is useful in several ways. It helps elucidate biological mechanisms, aids empirical research, and may lead to polygenic scores that provide information on individuals who are at risk for various outcomes.

Hyman asked Cesarini if behavioral prediction from genetic data could be imagined in 5 years if many hundreds of thousands of people have been studied for behavioral phenotypes of interest. He replied that behavioral genetics will become increasingly valuable in some settings. The power of prediction will vary across the complexity of the phenotype. He explained that eye color is comparatively easier to determine from DNA samples because there are just a handful of specific genetic variants that govern the vast majority of variability in eye color in the population, in contrast to height, for which there are thousands of genetic effects, each contributing a very little bit to the overall expected physical trait.

Neale interjected a point to consider about the nature of predictions: average is a good bet if additional information is not available.

DISCUSSION

George Gerliczy (Central Intelligence Agency) pointed out that the intelligence community studies individuals a great deal, but it usually looks at foreign leaders, leaders of countries or militaries, or terrorist organizations and makes any predictions about tendencies from a distance. Gerliczy pointed out that analysts in the IC are generally not psychologists, although there are some medical professionals conducting medical and psychiatric assessments of select foreign leaders.

Gerliczy offered that, like many other uses of advancing technologies, the IC is concerned with understanding how other nations or adversaries apply the insights from behavioral genetics in their actions. Such considerations require that the IC has enough analysts who are sufficiently familiar with the science and the capabilities to be able to speak intelligently about the policy implications.

Sallie Keller (Virginia Polytechnic Institute and State University) asked the panelists how privacy and privacy consent are managed in the international studies. Neale reported that their strategy is to divorce every individual identifier from the genetic data and phenotypic information, with the exception of individuals who are under an appropriate institutional review board (IRB) approval to maintain their information. He said he recognized the many ways of identifying individuals if their genomes or set of phenotypes could be picked out from records, and as such policies for safeguarding records become important considerations.

Hyman pointed out that he had just hired a global compliance officer for his institution to address concerns about the uses of personal data, including genomic data. He noted that people and governments are concerned about research data being accessed by the IC or by private companies like Google and Amazon. He emphasized the importance of issues about data handling and privacy for the research community.

A summit attendee asked if collecting personal information (genetic data and phenotypes) became ubiquitous from a young age, could it lead to predictions of a future leader's behaviors. Neale responded that it would be technologically feasible, but it was beyond his expertise to discuss the privacy implications. He said in terms of health care, it is less controversial to keep genotypic information as part of medical records and handled with safeguards to use as part of improving public health.

One of the summit attendees expressed concern that the presentations missed the idea that behavior is a fuzzy concept. For example, the framework or diagnostic category for schizophrenia changed between 2009 and 2014. In addition, there are differences internationally around diagnostic categories—there are some cultures where hearing voices is appreciated. The attendee encouraged the SBS Decadal Survey to pay serious attention

to studies on the role of the environment and not overemphasize phenotype genetic models.

Neale clarified that the core phenotypic definition of schizophrenia is the same. There is a group of people who lose their cognitive abilities at a very early age, have an erosion of their ability to structure their thoughts and emotions, and have hallucinations and delusions. Neale reiterated that there is clear evidence of genetic influences from a number of research approaches. He agreed that behavioral boundaries are fuzzy. For example, the genetic evidence from studies of schizophrenia and the genetic evidence from studies of bipolar disorder show a very high degree of overlap from a common variant genetic risk point of view.

Charles Gaukel (National Intelligence Council) followed up on Neale's comment that most people are average by definition. For many questions the IC considers, it is useful to know average conditions, and in many cases this information is not clear or available. Gaukel remarked that it would be useful to have models or mechanisms to characterize average conditions and also identify factors that would trigger someone or something to deviate from the average. For example, for many years, according to Gaukel, the Central Intelligence Agency has had a useful program called the Political Instability Task Force, which periodically assembles correlates to a country's vulnerability to instability and identifies countries at risk of domestic instability.

He said it would be helpful if science could address the time horizon challenge. As an analogy, he noted that correlates that put people more at risk for coronary disease are known (diet, lack of exercise); however, many of those in the populations at relatively high risk will not have a heart attack in any given year. Gaukel suggested the IC would be interested in learning more about indicators that suggest one is moving toward a tipping point or a position of higher risk.

Amy Kruse (Cubic Global Defense) pointed to research on how changes in brain chemistry are correlated with aspects of decision-making and risk-taking as well as susceptibility to persuasion. She asked whether this area of research could help advance predictions of behaviors and whether wearables and other physiological sensors might play a role in data collection. Hyman acknowledged this area of research could be useful, but current studies using brain imaging and electroencephalograms are very expensive, and so progress is advancing at a slower rate than the genetics work. The genetics work has progressed rapidly in the past decade because of decreasing costs of microarrays, computation, and sequencing, thus permitting the study of large numbers of humans to achieve statistical power. Hyman said there would have to be a similar cost revolution in the neurobiological tools to get to the levels of certainty needed.

Neale added that another reason for the success in the area of genetics is that the field has been concerned about and taken steps to control biases and confounding variables. He recognized that additional data from wearables or other devices could potentially be useful, but the biases and confounding variables that troubled earlier phenotypic studies will continue to be applicable and should be taken into consideration. Lessons learned from the genetics work include focusing on scale, consistent effects, statistical standards, and reproducibility.

Paul Glimcher stressed that even if every genome from every person on Earth was included in GWAS research, traits could not be predicted with 100 percent accuracy. Statistically, there is no linear end point. With such a complete database, the science could tell how much of the variability in the world was due to genetics. Glimcher emphasized it is important to recognize that the phenotype, or trait, is a combination of genetics and environment, and no amount of genetic data will ever eliminate that fact. He added that there may even be some variability that a complete knowledge of environment and a complete knowledge of genotype would not eliminate.

Hyman added that another reason research in genetics has been successful is that it is easier than working on the environmental contribution to phenotypes. People live for a long time and go through all kinds of experiences, making it difficult to understand the effect of environment and any gene-environment interactions.

As the discussion concluded, Keller noted the importance of the day's discussions in setting up issues for the SBS Decadal Survey to consider. She noted that analysts in the intelligence community are operating at a rapid pace with real problems. They want findings from research to support their work and to communicate these findings to policy makers effectively. She said the SBS Decadal Survey will need to examine the pace at which science is progressing and find ways to separate out knowledge relevant to the intelligence community and its operations.

Fourth Research Session: Risk and Decision-Making

The fourth research panel was moderated by Sallie Keller (Virginia Polytechnic Institute and State University) and showcased cutting-edge work in the area of decision sciences and risk. Panelists included David Broniatowski, assistant professor in the School of Engineering and Applied Science at George Washington University; Paul Slovic, professor of psychology at the University of Oregon; and Jeremy Wolfe, professor of ophthalmology and radiology at Brigham and Women’s Hospital and Harvard Medical School. Each panelist presented an overview of his research program and highlighted key findings, methodologies, data considerations, and relevance to the work of analysts in the intelligence community (IC).

COMMUNICATION STRATEGIES FOR BEHAVIOR CHANGE

David Broniatowski focused on what military doctrine calls the “battle of the narrative,” which involves communications strategies for behavior change, specifically on social media. His presentation explored the implications of communications strategies for national security and for public health and synergies between these fields.

Broniatowski illustrated directives from military doctrine on the importance of narratives. For example, Field Manual 3-24, the Counterinsurgency Field Manual,¹ emphasizes the ways that insurgents and counterinsurgents might use narratives to attempt to mobilize populations for good or for ill.

¹ Available at <http://usacac.army.mil/cac2/Repository/Materials/COIN-FM3-24.pdf> [January 2017].

Joint Doctrine Note 2-13 emphasizes the role of social media, in particular as a medium for the rapid transmission of information and misinformation and how social media can be something that is used to motivate populations to take actions, whether for good or for ill.

On the importance of narratives, Broniatowski highlighted a quote from a special issue of *Vaccine*² in the context of vaccine refusal: “Narratives have inherent advantages over other communication formats. They include all of the key elements of memorable messages. They are easy to understand. They are concrete and credible. And they are highly emotional. These qualities make this type of information highly compelling.” He said that compelling narratives are generally assumed to lead to behavior change.

Broniatowski presented statistics to illustrate that more and more people receive their news and information from social media. For example, 80 percent of Internet users seek information about their health online. Sixteen percent seek information about vaccines online. Among millennials, 61 percent get most of their news from social media. Calling attention to Facebook, he noted that 81 percent of all article shares are Facebook posts, and 71 percent of all online U.S. adults are on Facebook. He suggested that this major social media platform may be responsible for informing a significant portion of the U.S. population.

In considering the role of narratives in public health, Broniatowski drew attention to well-organized antivaccine campaigns that often exploit the use of social media. He noted that these campaigns generally make use of decontextualized facts, manipulating them to fit an existing narrative. A common approach is to present sequential events as if they are causal conclusions, when they are really spurious correlations. Broniatowski illustrated this approach with an example about the Zika virus. He noted that a recent report, released in South America, claimed that Monsanto’s release of the larvicide pyriproxifen, not the Zika virus, was responsible for microcephaly. According to Broniatowski, the report had a number of factual inaccuracies, but it became a major anti-Zika story for a short period of time.

Earlier this year, he conducted a study analyzing tweets about the Zika virus, identifying the posts that contained pseudoscientific claims and examining the characteristics of the people transmitting these pseudoscientific tweets. He found that about 85 percent of them had previously tweeted about vaccines within the previous year. A majority of these people, at least 57 percent, had previously tweeted a similar antivaccine message. He determined that although the context was different, some people with an

²See Betsch, C., et al. (2012). Opportunities and challenges of Web 2.0 for vaccination decisions. *Vaccine*, 30:3730.

antivaccine message seemed to put together new information into an existing narrative. According to Broniatowski, the social media conversation became an issue of great public health concern when a significant number of people seemed to buy into the idea that Zika was not causing microcephaly.

Broniatowski introduced the concept of fuzzy trace theory to help explain why some of these claims are compelling and what is driving some of these behaviors. Fuzzy trace theory, a leading theory of decision under risk, posits that there are two types of memory: (1) verbatim memory or memory for precise details, such as statistical figures; and (2) memory that encodes the basic meaning or the gist or bottom line of an idea. According to Broniatowski, research has shown that people tend to make decisions based on gist memories preferentially when compared to verbatim memories. He pointed out that fuzzy trace theory predicts that stories are going to be effective because they communicate a gist. He suggested that websites that produce coherent or meaningful gists that cue relevant moral and social principles will be more influential and compelling than websites with a lot of decontextualized or unstructured factual information.

Broniatowski shared results from another study he conducted to test fuzzy trace theory. About 4,500 articles published between November 2014 and March 2015 related to the Disneyland measles outbreak were coded as to whether they contained statistics about viruses or vaccines, whether they contained a gist or bottom-line meaning, and whether they contained a story. The study also measured how frequently these articles were shared on Facebook. It found that articles with a gist were significantly more likely to be shared than articles that did not express a gist. Articles with a gist that mentioned both sides of the vaccine debate were about 58 times more likely to be shared than articles with a gist that did not mention both sides.

Broniatowski is now working on a gist communication framework. The steps of the framework include communicating the verbatim (evidence, research findings), then linking the evidence to a bottom-line meaning or suggestion for one's actions. He drew attention to the need for cultural sensitivity when relating the evidence to something of value to the audience. He explained that this means understanding the values and norms of the communities in order to effectively communicate with them.

In closing, Broniatowski offered ideas for future research directions that can increase understanding of these values and norms. Specifically, he is exploring how data can be collected from social media in a synergistic fashion with existing survey techniques. He expressed the hope that the same norms and practices that now characterize rigorous survey sampling can be developed for sampling across social media platforms. He suggested that data from social media could complement survey data in a number of ways, reducing the speed of sampling as well as the cost and oversampling the

populations that surveys undersample. Analysis of social media data may also lead to pretesting hypotheses before developing more in-depth surveys.

PSYCHOLOGICAL PERSPECTIVES ON NATIONAL SECURITY

Paul Slovic reviewed five different domains of interest to national security and illustrated how they can be studied systematically with a behavioral orientation:

1. perceived risk of terrorist attacks,
2. economic impacts of these risk perceptions,
3. risk communication strategies for increasing resilience after a terrorist attack,
4. development of a strategy for deterring unstoppable terrorist attacks, and
5. consideration of the question of whether humanitarian values collapse when they conflict with national security objectives.

Slovic pointed out that risk perception has been studied systematically for decades. Research has sought to understand how people interpret risk, the factors that determine their perception and acceptance of risk, the role that emotion and reason play in risk perception, and the social and economic implications of these perceptions. Within the context of terrorism, the research questions have included how perceptions of terrorism risk compare to disasters and other accidents; how different types of terrorist activities/actions compare with each other; how risk perceptions can be used to forecast the impacts that these events will have on society; and whether risk communication strategies can reduce harmful social, political, and economic overreactions to terrorist attacks.

In studying perceived risk of terrorist attacks, Slovic's research program has used hypothetical damage scenarios that involve terrorism and non-terrorism events. In either case, the damages were the same in terms of harm to people attending a theme park in Southern California, the mechanism was either explosion or disease. In addition, the scenarios varied by the motive of the attackers and the victims, such as whether the attacker had a suicide intent or whether the victims were visiting officials or tourists. The number of people who were killed in an event ranged from 0 to 495. Slovic presented a short story line of an attack at a theme park to illustrate an example of a scenario. Keywords varied from one story to another to change the context of the event. Slovic reported that the keywords were systematically manipulated within the standard scenario frame in order to assess how they affected the dependent variables, which were based on a questionnaire about risk perception, trust in officials, and the like. He

indicated that study subjects were also interviewed about their behaviors, such as whether the damaging event would stop them from going to theme parks or outdoor places in general.

Slovic reported findings from the research. The research subjects perceived the anthrax and bomb scenarios defined as terrorism as much higher risk than the same level of damages done through a propane explosion or infectious, non-anthrax disease. Subjects were more worried about anthrax than a bomb, which he surmised is, in part, because a bomb is more defined in space and time than anthrax. Another finding was that terrorism events compared to other events with the same damages were associated with greater perception of risk, less trust in first responders, greater trust in government officials, and less confidence in the ability to protect oneself. Other noted behaviors with terrorism included more attention to the news media and greater perceived need to contact friends and family.

Slovic also sought to quantify the impacts of different types of events within a conceptual framework that asserts that risk perceptions drive behaviors that can have enormous social, economic, and political impacts after a terrorist attack.³ In one study, subjects were interviewed about their response to a hypothetical but realistic scenario: a dirty bomb explosion in the financial district of Los Angeles that scattered radioactive material around several blocks in the downtown area but was cleaned up over time. Subjects were asked if they would work in, shop in, or visit this area. Slovic worked with economists to assess economic costs of the different reactions. The research found that the indirect costs driven by behavioral reactions due to fear and the stigmatization of the attack location may be far greater than the direct costs associated with the physical damages—an estimated 15 times greater than the direct damages in one case that was studied. He noted the cost multiplier would vary with event and context and suggested that further research could help identify what factors associated with a terrorist attack would trigger greater or lesser impacts.

In regard to risk communication strategies, Slovic referred to research on a concept borrowed from social psychology called inoculation messaging, which can be used to prepare people in advance for an event by giving them a brief exposure to the possibility, analogous to a vaccination. A sample message might be, “These attacks will happen. The officials have prevented many such attacks. They are doing a lot of things that are competently working to minimize these attacks. The intent of terrorism is to disrupt lives and society. They want you to overreact, etc.” In one study of inoculation messaging and responses to a terrorist event, the research found

³A theory called the social amplification of risk, designed principally by Roger Kasperson and colleagues. See Kasperson, R.E., et al. (1988). The social amplification of risk: A conceptual framework. *Risk Analysis*, 8(20):177-187.

that the group that received the inoculation message had a very strong and somewhat lasting effect of a much more restrained response, with less loss of confidence in officials, than was found in a control group that did not get the message. Slovic recognized it was only a single study, but felt it illustrated the possibility that communications can be used strategically to make society more resilient to these attacks.

Slovic then referred to findings from research that might be used to help understand what might demotivate people from committing attacks. Potentially important insights were found in studies examining how to motivate people to help others in need, such as children facing starvation in various countries. This research found that nonrelevant sources of negative feelings can create an illusion of nonefficacy that demotivates people from helping others even when they are capable of helping. He reported that the donations to a charity helping children in need dropped almost in half when the statistics of starvation were put in the same frame. Such a presentation, according to Slovic, made people feel bad by making them aware that although they could help one child, they could not help millions more. A similar loss of good feelings and less willingness to donate also occurred when the communications showed a small number of children that could not be helped or unrelated highly negative pictures such as a dog snarling, a shark baring its teeth, or a handgun. In sum, certain conditions created a feeling of nonefficacy in people who were capable of doing good things for the children.

Slovic and colleagues hypothesize that, in much the same way, a way to deter terrorists may be to create an illusion of nonefficacy, introducing cues or other stimuli that would diminish the perceived efficacy of what they were considering. He noted that research such as the studies of children described above, shows that emotions let in irrelevant sources of negative affect that can confuse capable people about their efficacy. He suggested that academics and security experts, including those with cultural and social knowledge about the populations from which terrorists come, work together to develop ways to use these insights to demotivate attackers from attempting to cause harm.

On his final point that life-preserving interventions are devalued when they conflict with national security, Slovic described three obstacles to responding to humanitarian crises: psychic numbing, pseudo inefficacy, and prominence bias in decision-making. He suggested that decision makers need to be aware of the subtle way that their decisions may contradict their expressed values through the overweighting of national security and the diminishing of the importance of protecting human lives. He suggested the use of well-regarded structured decision-aiding techniques in top-level decision-making. This approach induces decision makers to think more

carefully about the tradeoffs between conflicting objectives and brings expressed values and values implied by decisions into closer agreement.

HOW VISUAL ATTENTION LIMITS VISUAL PERCEPTION

Jeremy Wolfe considered the visual attention space of experts who are trying to detect threats. He noted that threats can be missed, not just in unmonitored or poorly monitored spaces, but also in well-monitored systems. He reviewed five psychological challenges that explain why threats are missed: profusion, spatial uncertainty, inattentional blindness, prevalence of a threat, and the ambiguity of that threat.

Wolfe recognized that the challenges of profusion tend to be obvious. Technology increasingly produces too much information for anybody or any group of people to monitor. For example, a chest x-ray used to be a picture with ribs on it. Now, advanced technology can produce hundreds or thousands of images from different orientations that cannot all be scrutinized at the same level by radiologists.

To illustrate spatial uncertainty, Wolfe showed the audience a picture of coffee beans with hidden faces and ladybugs.⁴ It was difficult for the audience to find all the faces and ladybugs that were scattered within and camouflaged by the coffee beans. Not knowing where to look makes a difference in one's sensitivity to stimuli, he said. He also noted that people tend to miss a second target after one target is found, a phenomenon known as satisfaction of search. This happens even if the targets could have been found in isolation.

To illustrate inattentional blindness, Wolfe asked the audience to find a set of golf balls in a picture of a miniature golf course. Some golf balls were notably on the green, but others were in the trees. Wolfe called inattentional blindness a curse of expertise: that is, if people know where something should be, they tend not to look in unusual or atypical places. This learned behavior can be useful in many situations, such as knowing where to look for signs when driving down a highway.

In a research study of inattentional blindness, Wolfe inserted a small picture of a gorilla into an X-ray of a lung.⁵ He reported that 20 of 24 radiologists failed to report the gorilla. Although the radiologists were asked to screen for lung cancer, they were also supposed to keep an eye out for incidental findings. However, their experience and adaptive behavior allowed them to miss something significantly out of place. Wolfe queried why people

⁴See, for example, <http://www.moillusions.com/hidden-coffee-faces-and-bugs/> [December 2016].

⁵See Drew, T., Vo, M. L.-H., and Wolfe, J.M. (2013). The invisible gorilla strikes again: Sustained inattentional blindness in expert observers. *Psychological Science*, 24(9):1848-1853.

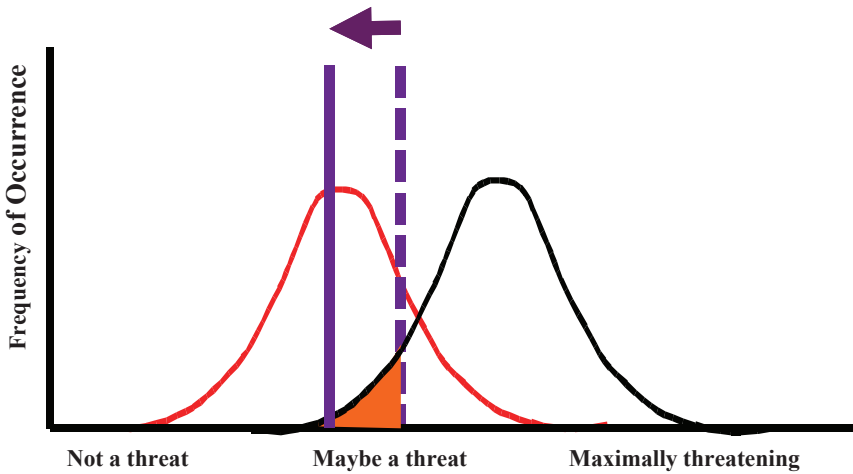


FIGURE 7-1 Continuum of threats.

NOTE: Distributions of nonthreats and threats often overlap. If one needs to make decisions between threats and nonthreats, a criterion can be chosen (dotted line). If the error of missing a threat is unacceptable, the criterion can be moved to the left (solid line). However, this increases the rate of false positives or false alarms. SOURCE: Adapted from Wolfe, J. (2015, October 5). *How the heck did I miss that? How visual attention limits visual perception*. Presentation at the Summit on Social and Behavioral Sciences for National Security, Washington, D.C.

do not see what is right in front of them. He used the word “gist” a little differently from Broniatowski, arguing that people see the gist, which he defined as a limited amount of semantic information about visual stuff in front of them. According to Wolfe, a person attends to and fully recognizes only one or maybe a very small number of objects at any one time. If something changes in the view for a moment but does not change the visual gist of the scene, a person likely will not notice it.

Wolfe pointed out that many visual searches are for rare or low-prevalence events, such as threats at baggage screening, cancer in breast cancer screening, and terrorist attacks. He noted that research has determined that threats or targets in a low-prevalence context are missed at a higher rate than threats or targets in a high-prevalence context.⁶

On the problem of ambiguity, Wolfe illustrated a continuum, in which

⁶See, for example, Evans, K.K., Birdwell, R.L., and Wolfe, J.M. (2013). If you don't find it often, you often don't find it: Why some cancers are missed in breast cancer screening. *PLoS ONE*, 8(5):e64366.

some things are very clearly threats and others are not so clearly threats. Similarly, there are nonthreats and not-so-clear nonthreats (Figure 7-1). A decision boundary (or criterion) placed on the continuum could lead to correct determination of threats and nonthreats (true positives and true negatives) but could also lead to errors (false positives and false negatives). Wolfe pointed out that the choice of a decision boundary is a choice around which type of errors will be tolerated more.

In closing, Wolfe summarized that people's visual systems have limited capacity. He recognized that technology is expanding the amount of visual information that could be considered. He reiterated that targets can be missed in a search if they are rare occurrences or ambiguous. They also can be missed if in unusual locations. Wolfe suggested that future research further explore people's limitations and examine countermeasures.

DISCUSSION

George Gerliczy (Central Intelligence Agency) noted Broniatowski's presentation mentioned pseudoscientific claims, which reminded him of conspiracy theories. He pointed out that the CIA is often the target of conspiracy theories and, therefore, the theories are of great interest. He provided an example of working with academic experts to develop an analytic framework to help think about conspiracy theories. The academics were asked to consider factors that make people either more likely to believe in or more likely to spread conspiracy theories. He noted interest on three different levels: (1) individuals—what is it that makes them more or less likely to embrace conspiracy theories? (2) groups—what does the group interaction look like? and (3) societies or culture—what makes a large group generally more or less likely to embrace conspiracy theories? The academics also provided advice on countermeasures, some of which were counterintuitive.

He said the intelligence community is interested in knowledge about risk perception and reactions to risk at the levels of individuals or leaders, organizations, and broader society. He emphasized that the CIA focus is overseas, but other IC agencies with a domestic mandate may be more interested in domestic applications to build societal resilience to risk and mixed messaging.

Slovic observed that in regard to the importance of gist, narratives may oversimplify complex situations, which can lead to actions that on more careful reflection might not be taken. He pointed to research on imperatives, which he defined as seemingly self-evident statements that guide decisions. Research examined Lyndon Johnson's decision to expand combat in Vietnam based on the imperative to stop the spread of communism and George Bush's decision to enter Iraq based on the notion that Saddam

Hussein had weapons of mass destruction. Slovic suggested that such compelling imperatives may make the decision seem obvious and thus, at times, can cut short careful analysis and deliberation.

With regard to Wolfe's discussion of situations that overwhelm visual attention, Slovic pointed to his own research examining people's willingness to help others. He found when a person has two or more people to consider, rather than just one, he or she is likely to feel less sympathy and less motivation to help them because the motivation to help is driven by attention, and his or her attention is spread among two or more people, limiting the development of an emotional connection to the people in need.

Steve Rieber (IARPA) asked Slovic to clarify whether he saw the secondary effects of terrorist attacks as an irrational overreaction, or as rational and perhaps even necessary to prevent a much larger subsequent attack. Slovic said his research found very strong reactions, with large societal costs, as secondary effects. However, he said, whether or not they are overreactions needs to be debated to determine appropriate levels of response and costs society is willing to bear to protect national security.

Charles Gaukel (National Intelligence Council) pointed out that in his experience, when faced with making decisions or judgments in situations of high uncertainty, people often resort to reasoning by analogy. He asked about the use of analogies—when people use them, when they are appropriate and when not, and the pitfalls and advantages. Slovic recognized a large research literature on reasoning by analogy. He asserted using an analogy could be a problem when it is too much of a shortcut in complex decisions with multiple objectives and cuts off more careful analysis.

Another attendee emphasized the importance of continuing to consider the issue of reasoning by analogy. The attendee noted that things can be similar in terms of superficial characteristics, or they can have deep similarities. Research has examined the use of analogies to improve decision-making by giving people simple appropriate analogies to reduce cognitive biases such as base rate neglect.

Stuart Umpleby (George Washington University) recognized that social systems, as opposed to physical systems, consist of purposeful actors, namely individuals and institutions, who tend to change their mind and behave differently at different times. He asked if the SBS Decadal Survey would consider expanding the conception of science so that it more adequately encompasses social systems. Keller responded that it probably would.

Broniatowski provided more information on the role of cultural sensitivity. When addressing a particular conspiracy theory or pseudoscientific claim or any claim, Broniatowski noted it is important to understand how that gist interfaces with a person's cultural background, which is ultimately the gist to that person. For example, in the antivaccine debate, according

to Broniatowski, when it was believed that thimerosal in vaccines caused autism, the CDC response and message was to remove thimerosal from the vaccine. Antivaccine supporters changed their narrative to that in which autism is caused by other toxins present in vaccines. Broniatowski suggested that the high-level gist for this group is that the government is trying to poison citizens and cannot be trusted. He noted that these claims, now incorporated into some people's worldviews, can come from legitimate sources, such as history related to the Tuskegee syphilis experiments. He summarized that if a narrative focuses on specific findings and statistics, the bottom line is open to interpretation of those findings through whatever lens a particular community may be using. He proposed that there would be value to speaking specifically to a gist that a community understands backed up by facts.

A summit attendee asked Broniatowski to follow up on the characteristics of online antivaccine supporters and any intervention strategies. Broniatowski noted that studies of the antivaccine campaigns have found some hard-core supporters but a much wider range of people who are simply vaccine-hesitant. The emphasis is to intervene with those who are vaccine-hesitant rather than necessarily targeting the people who have a strong commitment to their opposition. The research field, according to Broniatowski, is looking to identify particular online networks, following the patterns and links of social media communications.

Gerliczy recognized that the nature of the work in the IC is much like that in health care, in terms of grappling with risk and uncertainty, high stakes, volume of information, and the regularity in which decisions are made. One difference, according to Gerliczy, is the amount of disinformation and misinformation. IC analysts often have to discern whether information offered or collected is informative or distracting. He acknowledged that any research or knowledge that can help improve the way in which the IC processes information to make sound decisions would be helpful.

Wolfe pointed out that one advantage of medical searches is that diseases typically are not trying to hide. Almost all IC-related threats keep changing. When the rules of a situation change, it takes a while for the analytic expertise to adapt. He suggested the IC needs to consider whether its training is responding to last year's threat.

Mitchell Mellen (Office of the Director of National Intelligence) asked Wolfe about the implications for machine learning or deep learning to augment human perception. Wolfe said it depended on the task. If a machine can do the task at an error rate that can be tolerated, then it can be useful. He said, "A good breast cancer computer-aided detection system, for instance, will detect about 90 percent of the cancers and false-alarm about 10 percent of the time, which is on the order of what an expert radiologist will do." If there are 1,000 cases, 3 with cancer, the system would identify

all the cancer cases but also false-alarm 100 times. This false-alarm rate might be tolerated in order to catch the 3 cases with cancer. By analogy, he said, a suggestion of 3 good restaurants for every 100 bad ones would be less appreciated. Wolfe pointed out that an understudied problem is the interaction of computer systems with the human expert.

Claudio Cioffi-Revilla (George Mason University) asked the panelists how they developed their sense of what is important and relevant for the purpose of intelligence analysis. Wolfe responded that the most useful tool is to have access to the relevant domain experts. "There is nothing like sitting with baggage screeners or radiologists or image analysts . . . and listening to what they [say] they are doing," he commented. The challenge is time, he added: practitioners and analysts are busy and cannot be accessible for all the work that would be interesting in the research lab.

Broniatowski pointed out that he worked for a small defense firm before becoming an academic. Trying to make research relevant to the IC, he said, is a process of self-correcting through experience and feedback from the people who may find the tools or information useful. Gerliczy articulated that the IC, as part of the SBS Decadal Survey, is committed to engagement with academics to help bridge the gaps.

A webcast participant asked about any studies within the IC on group decision-making or processes. Gerliczy reported on work to understand how to make better decisions internally. There have been particular emphases after significant events. These efforts, according to Gerliczy, have been geared around mitigating the biasing effects of judgment and decision-making heuristics.

A second webcast participant asked Wolfe to identify any workarounds and countermeasures to address attentional bottlenecks. Wolfe pointed out that a straightforward workaround is to put more eyeballs or more cognitive systems onto the same problem (i.e., independent sets of analyses). Another way is to have an initial filter that narrows down the task to what should be examined or might be suspicious without worrying about false-alarm errors. This cuts down the profusion of spatially uncertain stimuli, and then a smaller set is analyzed.

Summative Remarks

The summit closed with a panel of participants, including the steering committee members, representatives from the intelligence community, and an invited discussant, to sum up what they learned at the summit and identify gaps and opportunities deserving attention in the SBS Decadal Survey.

As invited discussant, Robert Fein (National Academies Intelligence Community Studies Board) reiterated that the survey is an important and much-needed opportunity to offer methodologies, knowledge, and insights from the social and behavioral sciences (SBS) to the professionals in the U.S. intelligence community (IC). Presentations at the summit have suggested the breadth and depth of expertise and information that is and will be available to the IC. Fein encouraged the audience to contribute to the project to expand the range of knowledge and insights considered. He offered his own ideas of what those contributions might entail:

- *Understand the interests and needs of the IC:* What questions does the IC have regarding the content and process of its analyses and operations? What SBS areas are of most interest?
- *Find ways to express both what is known and what is not known:* Fein recognized that several presenters articulated the limits of current and likely future knowledge in their areas of expertise.
- *Suggest rough timelines about where a body of research can be in 3 years or 10 years:* Fein encouraged contributors to identify realistic development stages, barriers to progress, and priority areas where new knowledge is needed.

- *Facilitate effective communication:* Fein noted a need for translating SBS data and knowledge and explaining it in terms that make sense to IC analysts, operators,¹ and policy makers.
- *Seek assistance from and possible collaboration with existing organizations:* Fein identified the Center for Research in Evidence of Security Threats in the United Kingdom as one such resource.

GENERAL DISCUSSION

Bear Braumoeller (The Ohio State University) expressed excitement about the presentations and studies at the summit. However, he pointed out that social scientists who carry out research on national security and international relations were underrepresented. These researchers spend a lot of time grappling with research challenges, he noted, such as ecological inference issues and drawing causal inferences from observational data. For example, he said, there is no way to do experiments when one is trying to understand countries and what makes them go to war. He saw great potential for collaboration between his discipline, political science focused on international security studies, and the disciplines presenting at the summit. He noted that the SBS Decadal Survey is a good opportunity for academic communities to interact and learn more about each other, and a variety of international security centers would be willing to be part of the conversation and host town halls as part of the project.

Erica Chenoweth (University of Denver) asked how the social sciences would fit into the SBS Decadal Survey. She noted that other levels of analyses, beyond the individual level, were not represented well at the summit. Many major problems of national security, she said, do not emerge from individual decision-making, conscious or unconscious, but rather from cases where group life determines collective behavior. In many situations, empirically demonstrated characteristics, structures, and systems of countries influence whether they fight one another or not. Chenoweth said that research in the social sciences, or analyses at the group or society level, would be a better fit to the types of questions posed at the summit by IC representatives regarding the instability of leadership or the consolidation of political powers. Thomas Fingar (Stanford University) recognized that the summit represented a partial cut into the problem. As the SBS Decadal Survey proceeds, he said attention would be brought to sociology, political science, economics, and other disciplines as the project considers different levels of analyses—from individuals and individual cognition and action—to groups' collective decision-making and impacts on society's stability.

¹In regard to the intelligence community, operators refer to the personnel in the field, either those collecting information or those making decisions from the analyses.

Steven Hyman (Harvard University) suggested that the model presented by Joshua Epstein (Johns Hopkins University) tried to bridge some of these levels (see Chapter 5), but noted that studying cross-level connections is very challenging. Epstein added that his *Agent_Zero* work has illustrated that there are cases where a group as a collective entity will unanimously take an action that no member of the group would take alone. Charles Gaukel (National Intelligence Council), drawing on his IC experiences, observed that people have multiple identities that can be evoked differently under different circumstances and under perceptions of threat. The identity that matters most is situationally dependent.

Valerie Reyna (Cornell University) pointed out that people have agency and can change the way they interpret things. Emotions are not only a function of biological underpinnings, but are also a function of how reality is interpreted. Often, she said, genetics, biology, or even cultural groups are construed as immutable. However, research has found, for example, that while the brain has certain responses to fear and that different cultures have certain differences, these things can be changed.

Deanna Caputo (MITRE Corporation) agreed with others on the absence of social sciences at the summit, but anticipated the SBS Decadal Survey would cover them. She noted IC representatives frequently brought up the notion of culture, which should be considered in the project. She cautioned that the research is very domestic-focused, and it may be difficult to find arguments and findings that translate, knowing that behavior is very different from culture to culture. She concurred with Reyna's point on change in people and recognized that the summit presenters did not talk about mitigation (a term computer scientists use in cybersecurity work). She urged more applied research, and incentives to do so, focused on changing behaviors.

Another summit attendee said she appreciated the multidisciplinary approach to the summit and the SBS Decadal Survey. She suggested a few areas that were not covered that might be considered, including personnel selection and assessment, insider threats, effective interviewing, users and technology, and measuring effectiveness. She underscored that practices within the agencies could be informed by SBS research.

Margaret Polski (George Mason University) drew attention to other disciplines that should be considered in the SBS Decadal Survey: human-systems integration, quantum computing, computational social science, and operations research. She pointed out that the SBS Decadal Survey will have practical value beyond intelligence analysis since this analysis informs policy-making, strategy, and operational design. She emphasized that it is important to keep in mind that the methodologies, tools, and knowledge considered in the survey will feed into strategic behavior, which is different from deterministic behavior, and as such has to be approached in a very different way.

Stephen Balfour (Texas A&M University) suggested two programs that might serve as examples of collaboration between the academic community and IC: the IC postdoctoral program and the Department of Defense Minerva Program. Charlie Rogan (Artis International) observed that researchers in the Minerva Program often do not feel connected to the policy community in the same vein as the stated goal of the SBS Decadal Survey. He reiterated that it would be useful to bridge gaps between communities and to develop an understanding of the challenges and difficulties in doing short-term analyses from the perspective of those in the IC.

CLOSING COMMENTS

In closing remarks, David Honey (Office of the Director of National Intelligence) thanked the presenters, discussants from the IC, staff at the National Academies, and the government staff. He recognized that the National Academies' ability to convene people from multiple disciplines and perspectives, as well as geographic areas, will prove valuable to the SBS Decadal Survey. He projected that after a 2.5-year consensus process requiring a lot of deliberative thinking, participants will end up at a higher level of understanding, and the survey will produce a quality report. He encouraged the audience to continue to participate in the project, visit the website,² provide ideas and research suggestions, and attend meetings and town halls. Honey made a special request to government personnel for input.

Sallie Keller (Virginia Polytechnic Institute and State University) closed by reminding the audience that the summit was designed to bring attention to the SBS Decadal Survey, expose the research community and the IC to some of the possibilities, and generate significant energy and excitement. She encouraged all participants to stay engaged and volunteer ideas and suggestions to ensure the survey's success.

²The website for the SBS decadal survey is at <http://nas.edu/SBSDecadalSurvey> [December 2016].

Appendix A

Social and Behavioral Sciences for National Security: A Decadal Survey Statement of Task

The Academies will carry out a decadal survey on the social and behavioral sciences (SBS) in areas relevant to national security in two integrated phases. The first phase, a national summit (workshop) to be held this fall, will help establish the framework for the survey and reinforce the commitment of the Intelligence Community (IC) to conduct a full decadal survey. Concurrent with the workshop, staff will begin to work on the second phase, including developing a slate of nominees for the survey committee and conducting other preparatory work (e.g., outreach to professional associations, identifying venues for town hall meetings). A steering committee will be appointed to plan the summit, a separate survey committee will be appointed to conduct the survey, drawing on the membership of the steering committee.

SUMMIT STATEMENT OF TASK

An ad hoc steering committee will organize a 1.5 day summit (workshop) in Washington, D.C. to highlight SBS research that may have relevance to the IC. The committee will plan and organize the summit, select and invite speakers and discussants, and moderate the discussions. A summary of the workshop presentations will be prepared by an independent rapporteur in accordance with institutional guidelines.

DECADAL SURVEY STATEMENT OF TASK

An ad hoc consensus committee will be appointed to conduct the decadal survey aimed at identifying opportunities that are poised to contrib-

ute significantly to the IC's analytic responsibilities. The study will identify opportunities throughout the social sciences (e.g., sociology, demography, political science, economics, and anthropology) and from behavioral sciences (e.g., psychology, cognition, and neuroscience) and will draw on discussions at the summit to frame its inquiry. Attention will also be paid to work in allied professional disciplines such as engineering, business, and law, and a full variety of cross-disciplinary, historical, case study, participant, and phronetic approaches.

The committee will work with Office of the Director of National Intelligence (ODNI) and security community members to understand government needs and expectations. The final report will be based on the committee's consideration of broad national security priorities; relevant capabilities of elements within the security community to support and apply SBS research findings; cost and technical readiness; likely growth of research programs; emerging SBS data, procedures, personnel, and other resources; and opportunities to leverage related research activities not directly supported by government. The committee will specify a range of relevant work that could be useful to the IC for their consideration in developing future research priorities.

The committee's primary tasks will be:

- Assess progress in addressing selected major social and behavioral scientific challenges that might prove useful to national security. Include discussion of approaches that are gaining strength and those that are losing strength. Where possible, rely on published meta-analyses.
- Identify SBS opportunities that can be used to guide security community investment decisions and application efforts over the next 10 years.
- Specify approaches to facilitate productive interchange between the security community and the external social science research community.

Appendix B

Summit Agenda and List of Participants

SOCIAL AND BEHAVIORAL SCIENCES FOR NATIONAL SECURITY SUMMIT

AGENDA

October 4–5, 2016

National Academies of Sciences, Engineering and Medicine
2101 Constitution Ave., NW
Washington, DC

Auditorium

Day One: Tuesday, October 4

- 9:00 a.m. **Welcome and Overview of Meeting**
Sallie Keller, Summit Committee Chair
- 9:10 a.m. **Welcome from the National Academies of Sciences,
Engineering, and Medicine**
Marcia McNutt, President, National Academy of Sciences
- 9:30 a.m. **Sponsor's Perspectives**
David Honey, Director of Science and Technology at the
Office of the Director of National Intelligence
- 9:50 a.m. **Past, Present, and Future: The Intelligence Community Needs
of the Social and Behavioral Sciences**
George Gerliczy, Office of Strategic Programs, Central
Intelligence Agency
Geoffrey Strayer, Defense Intelligence Agency
Charles R. Gaukel, National Intelligence Council

10:50 a.m. **BREAK**

Moderator: Valerie Reyna, Cornell University

11:00 a.m. **Brain and Neuroscience**

Paul Glimcher, New York University

Title: Synoptic Data for Integrating the Social, Behavioral and Biological Sciences: The Kavli HUMAN Project

Read Montague, Virginia Polytechnic Institute and State University

Title: The New New Neuroscience: Extending the Reach of Modern Approaches to Brain and Mind

Elizabeth Phelps, New York University

Title: Emotion and Decision Making

12:00 p.m. **Discussion: Moderator, Speakers, and IC Representative**
(Charles Gaukel)

12:30 p.m. **LUNCH**

Moderator: Thomas Fingar, Stanford University

1:45 p.m. **Social Interaction**

Joshua Epstein, Johns Hopkins University

Title: *Agent_Zero* and Generative Social Science

Susan Fiske, Princeton University

Title: Stereotyping and National Security: Inequality and Conflict—or Peace

Mathew Burrows, Atlantic Council

Title: What Kind of Future World?

2:45 p.m. **Discussion: Moderator, Speakers, and IC Representative**
(George Gerliczy)

3:15 p.m. **BREAK**

Moderator: Steven Hyman, Harvard University

3:25 p.m. **Behavioral Genetics**

Benjamin Neale, Harvard Medical School

Title: Behavioral Genetics and Polygenic Inheritance

David Cesarini, New York University

Title: Predicting Behavioral Traits from Genomic Data

4:15 p.m. **Discussion:** Moderator, Speakers, and IC Representative
(George Gerliczy)

Moderator: Sallie Keller, Virginia Polytechnic Institute and State University

4:45 p.m. **Day One Response and Discussion**

5:00 p.m. **ADJOURN**

CONCLUDE DAY ONE

Day Two: Wednesday, October 5

9:00 a.m. **Welcome and Recap of Day 1**
Sallie Keller, Summit Committee Chair

Moderator: Sallie Keller, Virginia Polytechnic Institute and State University

9:15 a.m. **Decision Sciences and Risk**
David Broniatowski, George Washington University
Title: Communication Strategies for Behavior Change
on Social Media: Implications for Public Trust in
Government in the Face of Conspiracy Theories
Paul Slovic, University of Oregon
Title: Psychological Perspectives on Terrorism, National
Security, and Human Rights: Research Findings and
Future Directions
Jeremy Wolfe, Brigham and Women's Hospital, Harvard
Medical School
Title: How the Heck Did I Miss That? How Visual
Attention Limits Visual Perception

10:15 a.m. **Discussion:** Moderator, Speakers, and IC Representative
(George Gerliczy)

10:45 a.m. **BREAK**

Summation and Implications

11:15 a.m. **Summation, Discussions, and Suggestions for Decadal Survey**
Moderator: Sallie Keller, Summit Committee Chair

Summative Comments

Robert Fein, member, Intelligence Community Studies Board,
National Academies

General Discussion: Summit Steering Committee, David
Honey, George Gerliczy, Charles Gaukel, Robert Fein

12:15 p.m. **Closing Comments**

Sallie Keller, Summit Committee Chair

12:30 p.m. **ADJOURN**

This summit and a 2-year decadal survey to be conducted through the Board on Behavioral, Cognitive, and Sensory Sciences are sponsored by the Office of the Director of National Intelligence (ODNI).

LIST OF PARTICIPANTS

Summit on Social and Behavioral Sciences for National Security
October 4–5, 2016

COMMITTEE MEMBERS

Sallie Keller, Chair
Virginia Polytechnic Institute and
State University

Thomas Fingar
Stanford University

Steven E. Hyman
Harvard University

Valerie Reyna
Cornell University

Philip E. Tetlock
University of Pennsylvania

PRESENTERS

David Broniatowski
George Washington University

Mathew Burrows
Atlantic Council

David Cesarini
New York University

Joshua Epstein
Johns Hopkins University

Robert Fein
Member, Intelligence Community
Studies Board, National
Academies

Susan Fiske
Princeton University

Charles Gaukel
National Intelligence Council

George Gerliczy
Central Intelligence Agency

Paul Glimcher
New York University

David Honey
Office of the Director of National
Intelligence

Marcia McNutt
National Academy of Sciences

Read Montague
Virginia Polytechnic Institute and
State University

Benjamin Neale
Harvard Medical School

Elizabeth Phelps
New York University

Paul Slovic
University of Oregon

Jeremy Wolfe
Brigham and Women's Hospital,
Harvard Medical School

Geoffrey Strayer
Defense Intelligence Agency

ADDITIONAL PARTICIPANTS

Stephen Balfour
Texas A&M University

Kent Myers
Office of the Director of National
Intelligence

Bear Braumoeller
The Ohio State University

Margaret Polski
George Mason University

Deanna Caputo
MITRE Corporation
Erica Chenoweth
University of Denver

Steve Rieber
IARPA

Claudio Cioffi-Revilla
George Mason University

Charles Rogan
Artis International

Jytte Klausen
Brandeis University

Stuart Umpleby
George Washington University

Amy Kruse
Cubic Global Defense

Mitzi Wertheim
Naval Postgraduate School

Mitchell Mellen
Office of the Director of National
Intelligence

Jacqueline Wilson
Civic Fusion International

Irene Wu
Federal Communications
Commission

NATIONAL ACADEMIES STAFF

Barbara Wanchisen
BBCSS Director
Sujeeta Bhatt
Senior Program Officer

Julie Anne Schuck
Program Officer

Elizabeth Townsend
Research Associate

Hannah During
Senior Program Assistant

Renée L. Wilson Gaines
Senior Program Assistant

Appendix C

Biographical Sketches of Summit Planning Committee and Presenters

David Broniatowski (*Presenter*) is an assistant professor in the School of Engineering and Applied Science at The George Washington University and the director of the Decision Making and Systems Architecture Laboratory. He conducts research in decision-making under risk, group decision-making, system architecture, and behavioral epidemiology. This research program draws upon a wide range of techniques including formal mathematical modeling, experimental design, automated text analysis and natural language processing, social and technical network analysis, and big data. Current projects include a text network analysis of transcripts from the U.S. Food and Drug Administration's Circulatory Systems Advisory Panel meetings, a mathematical formalization of fuzzy trace theory, and a study using Twitter data to conduct surveillance of influenza infection and the resulting social response. He received his Ph.D. from the Massachusetts Institute of Technology.

Mathew J. Burrows (*Presenter*) serves as the director of the Atlantic Council's Strategic Foresight Initiative in the Brent Scowcroft Center on International Security. He was appointed counselor to the National Intelligence Council (NIC) in 2007 and director of the analysis and production staff in 2010. He was the principal drafter for the NIC publication *Global Trends 2030: Alternative Worlds*. In 2005, he set up and directed the NIC's Long Range Analysis Unit, now known as the Strategic Futures Group. Burrows joined the Central Intelligence Agency in 1986, where he served as analyst for the Directorate of Intelligence (DI), covering Western Europe. From 1998 to 1999 he was the first holder of the intelligence community

fellowship and served at the Council on Foreign Relations. Other previous positions include assignments as special assistant to the U.S. Ambassador to the United Nations Richard Holbrooke and deputy national security advisor to U.S. Treasury Secretary Paul O'Neill. He is a member of the DI's Senior Analyst Service. He received a Ph.D. in European history from Cambridge University.

David Cesarini (*Presenter*) is an associate professor in economics at New York University and a cofounder of the Social Science Genetic Association Consortium (SSGAC), which seeks to bring cutting-edge methods from medical genomics into social science genomics. Through the SSGAC, he has been involved in efforts to discover genetic associations with behavioral traits such as educational attainment, subjective well-being, and neuroticism. His work spans several areas, including health economics, labor economics, economics and psychology, and social science genetics. He received a Ph.D. in economics from the Massachusetts Institute of Technology.

Joshua M. Epstein (*Presenter*) is professor of emergency medicine at Johns Hopkins University (JHU), director of JHU's Center for Advanced Modeling, and codirector of its Systems Institute. He holds joint appointments in applied mathematics, civil engineering, economics, environmental health sciences, biostatistics, and international health and is an external professor at the Santa Fe Institute. A pioneer in agent-based modeling, Epstein has authored seminal books including *Growing Artificial Societies: Social Science from the Bottom Up*, with Robert Axtell; *Generative Social Science: Studies in Agent-Based Computational Modeling*; and *Agent_Zero: Toward Neurocognitive Foundations for Generative Social Science*. In 2008, he received an NIH Director's Pioneer Award and in 2010, an honorary doctorate of science from Amherst College, his alma mater. He holds a Ph.D. from the Massachusetts Institute of Technology and has taught at Princeton University and lectured worldwide.

Robert Fein (*Presenter*) is a national security psychologist who currently serves as a member of the National Academies' Intelligence Community Studies Board. For the past 35 years, he has worked to understand and prevent targeted violence, such as assassinations, workplace violence, stalking, school violence, and terrorist attacks. For more than 20 years, he worked with the U.S. Secret Service, consulting on protective intelligence cases and codirecting two operational studies on targeted violence (on assassination and school attacks). From 2003 to 2010, he served on the Intelligence Science Board (ISB), where he directed the ISB's Study on Educating Information. He has worked with intelligence, defense, and law enforcement organizations on the prevention of terrorist attacks and on counterintelligence. He

holds appointments at McLean Hospital/Harvard Medical School and the University of Massachusetts Medical School. He received a Ph.D. in clinical psychology and public practice from Harvard University.

Thomas Fingar (*Committee Member*) is a Shorenstein APARC Distinguished Fellow in the Freeman Spogli Institute for International Studies at Stanford University. From May 2005 through December 2008, he served as the first deputy director of national intelligence for analysis and, concurrently, as chairman of the National Intelligence Council. He served previously as assistant secretary of the State Department's Bureau of Intelligence and Research, principal deputy assistant secretary, deputy assistant secretary for analysis, director of the Office of Analysis for East Asia and the Pacific, and chief of the China Division. Between 1975 and 1986 he held a number of positions at Stanford University, including senior research associate in the Center for International Security and Arms Control. His most recent book is *The New Great Game: China and South and Central Asia in the Era of Reform*, for which he was editor and a contributor. He received an A.B. in government and history from Cornell University and an M.A. and a Ph.D. in political science from Stanford University.

Susan T. Fiske (*Presenter*) is the Eugene Higgins Professor in psychology and public affairs at Princeton University and currently chairs the National Academies Board on Behavioral, Cognitive, and Sensory Sciences. She investigates social cognition, especially cognitive stereotypes and emotional prejudices, at cultural, interpersonal, and neuroscientific levels. Author of over 300 publications, she has been elected to the National Academy of Sciences. Sponsored by a Guggenheim, her 2011 Russell Sage Foundation book is *Envy Up, Scorn Down: How Status Divides Us*. Her most recent book is *The HUMAN Brand: How We Respond to People, Products, and Companies* (with Chris Malone). With Shelley Taylor, she wrote four editions of the graduate text *Social Cognition*, and as sole author, three editions of an advanced undergraduate text, *Social Beings: Core Motives in Social Psychology*. She currently edits for *Annual Review of Psychology*, *PNAS*, and *Policy Insights from Behavioral and Brain Sciences*. She is a member of the National Academy of Sciences. She received a B.A. in social relations and a Ph.D. in social psychology from Harvard University.

Charles R. Gaukel (*Presenter*) is the counselor and chief of analysis and production staff of the National Intelligence Council (NIC). Prior to joining the NIC, he directed the Mission Performance Center in the Directorate of Analysis of the Central Intelligence Agency. From 2010 to 2012, he served at the National Geospatial Intelligence Agency as vice chair of the National Geospatial Intelligence Committee. Since joining the CIA as an analyst on

European issues in 1986, he has served in a variety of analytic staff and leadership positions. He has led or served as an analyst on a variety of all-source analytic units on Balkan, Central European, and West European issues. He served as the first director of political and leadership analysis training at the CIA's Sherman Kent School for Intelligence Analysis. He served as a reserve intelligence officer with the U.S. Navy, retiring in 2009 as a commander. He has also served as an editor/briefer on the President's daily brief staff. Among his awards, he received the Intelligence Commendation Award of the Director of National Intelligence (DCI), multiple CIA exceptional performance and meritorious unit awards, the DCI Balkan Service Award, and the Joint Service Commendation Medal. He holds a B.S. in education and an M.A. in political science from Kent State University, and completed graduate work in policy analysis and international relations at Virginia Tech and the Johns Hopkins School of Advanced International Studies.

George A. Gerliczy (*Presenter*) is an analytic methodologist in the CIA's Directorate of Analysis, a member of the Senior Analytic Service, and a member of the Senior Intelligence Service. He has experience drafting the full range of analytic products, including "current intelligence" pieces and longer-term assessments, as well as briefing senior agency officials and policy makers. He is currently a member of an analytic unit charged with providing strategic insights on all issues and geographic regions, with a focus on examining the most complex topics using rigorous and novel methods. He has spent years working with academic and other nongovernment experts to integrate findings from social and behavioral science into intelligence products and processes. He also served as a foreign service officer with the Department of State and, prior to his government service, as a senior associate at Standard & Poor's. He received a B.A. in mathematics and political science and an M.S. in public policy analysis from the University of Rochester, and an M.A. in security studies, with a concentration in international security, from Georgetown University.

Paul W. Glimcher (*Presenter*) is the Julius Silver professor of neural science, economics, and psychology at New York University (NYU), director of NYU's Institute for the Interdisciplinary Study of Decision Making, and director of the Glimcher Lab in NYU's Center for Neural Science. He founded the Center for Neuroeconomics in 2004 and later founded the Society for Neuroeconomics, the first academic society dedicated to the field. His research aims to describe the neural events that underlie behavioral decisions using tools from economics, psychology, and neuroscience. He is a fellow of the American Association for the Advancement of Science, the

McKnight Foundation, the Whitehall Foundation, the Ester A. & Joseph Klingenstein Fund, and the James S. McDonnell Foundation. He received the Margaret and Herman Sokol Faculty Award in the Sciences and NYU's Distinguished Teaching Award. He received his B.A. in neuroscience from Princeton University and his Ph.D. in neuroscience from the University of Pennsylvania, the first degree in neuroscience awarded by the university.

David A. Honey (*Presenter*) serves as the director of science and technology and as the assistant deputy director of national intelligence for science and technology in the Office of the Director of National Intelligence. He is responsible for the development of effective strategies, policies, and programs that lead to the successful integration of science and technology capabilities into operational systems. Prior to this assignment, he served as the deputy assistant secretary of defense, research, in the Office of the Assistant Secretary of Defense. He was the director of the Defense Advanced Research Projects Agency Strategic Technology Office, director of the Advanced Technology Office, and deputy director and program manager of the Microsystems Technology Office. He is a retired Air Force lieutenant colonel who began his military career as a pilot. He received a B.S. in photographic science from Rochester Institute of Technology, an M.S. in optical science from the University of Arizona, an M.S. in engineering physics from the Air Force Institute of Technology, and a Ph.D. in solid state science from Syracuse University.

Steven E. Hyman (*Committee Member, National Academy of Medicine Member*) is director of the Stanley Center for Psychiatric Research at the Broad Institute of the Massachusetts Institute of Technology and Harvard, a core member of the board, and Harvard University Distinguished Service professor of stem cell and regenerative biology. From 2001 to 2011, he served as provost of Harvard University, where he focused on the development of collaborative initiatives in the sciences and engineering spanning multiple disciplines and institutions. From 1996 to 2001, he served as director of the U.S. National Institute of Mental Health. He is the editor of *Annual Review of Neuroscience*, founding president of the International Neuroethics Society (2008-2014), and past president of the Society for Neuroscience (2015). He chairs the Forum on Neuroscience and Nervous System Disorders. He is a fellow of the American Academy of Arts and Sciences, American Association for the Advancement of Science, and American College of Neuropsychopharmacology, as well as a distinguished life fellow of the American Psychiatric Association. He received a B.A. from Yale College; a B.A. and an M.A. from the University of Cambridge, which he attended as a Mellon fellow; and M.D. from Harvard Medical School.

Sallie Keller (*Committee Chair*) is director for the Social and Decision Analytics Laboratory within the Virginia Bioinformatics Institute and professor of statistics at Virginia Polytechnic Institute and State University. Her previous positions include academic vice president and provost at University of Waterloo, director of the IDA Science and Technology Policy Institute in Washington, DC, William and Stephanie Sick Dean of Engineering at Rice University, head of the Statistical Sciences group at Los Alamos National Laboratory, professor of statistics at Kansas State University, and statistics program director at the National Science Foundation. Her areas of expertise are social and decision informatics, statistical underpinnings of data science, uncertainty quantification, and data access and confidentiality. She is a national associate of the National Academy of Sciences, fellow of the American Association for the Advancement of Science, elected member of the International Statistics Institute, and member of the JASON advisory group. She is also a fellow and past president of the American Statistical Association. She holds a Ph.D. in statistics from the Iowa State University of Science and Technology.

Marcia McNutt (*Presenter*) is a geophysicist and president of the National Academy of Sciences. From 2013 to 2016, she served as editor-in-chief of the *Science* family of journals. Prior to joining *Science*, she was director of the U.S. Geological Survey (USGS). Before joining the USGS, McNutt served as president and chief executive officer of the Monterey Bay Aquarium Research Institute (MBARI), in Moss Landing, California. During her time at MBARI, the institution became a leader in developing biological and chemical sensors for remote ocean deployment. She began her academic career at the Massachusetts Institute of Technology, where she was the E.A. Griswold professor of geophysics. She received a B.A. in physics from Colorado College and a Ph.D. in earth sciences at the Scripps Institution of Oceanography.

Read Montague (*Presenter*) is the founding director of the Human Neuroimaging Laboratory and the Computational Psychiatry Unit of the Virginia Tech Carilion Research Center at Virginia Tech, where he is also a professor of physics. He holds a Wellcome Trust Principal Research Fellowship at The Wellcome Trust Centre for Neuroimaging at University College London. In 2005-2006, he was a member of the Institute for Advanced Study in Princeton, New Jersey, and was a Kavli Fellow of the National Academy of Sciences in 2010. His work centers broadly on human social cognition, decision-making, and willful choice, with a goal of understanding the computational and neurobiological basis of these functions in health and disease. His group now employs novel approaches to functional neuroimaging, new biomarkers for mental disease, spectroscopy, real-time voltammetry, and computational simulations. He directs the Roanoke Brain Study, a proj-

ect aimed at understanding decision-making through the life span. His work has been published in *Nature*, *Science*, *Neuron*, and *PNAS*. He received his B.S. in mathematics from Auburn University and Ph.D. in biophysics from the University of Alabama at Birmingham School of Medicine.

Benjamin Neale (*Presenter*) is an assistant professor in the Analytic and Translational Genetics Unit at Massachusetts General Hospital, assistant professor in medicine at Harvard Medical School, and an associated researcher at the Broad Institute. With Mark Daly, he leads the ADHD Initiative, a collaborative effort that focuses on genomic studies of attention deficit hyperactivity disorder (ADHD). He has analyzed genetic data from large-scale studies of patients with ADHD, autism, age-related macular degeneration, type 2 diabetes, and metabolic disorders. He also analyzed data from the first ADHD genome-wide association study (GWAS) meta-analysis, which combined the results of four studies to boost statistical power. Neale contributed to the development of software tools such as PLINK and also led the design of the exome chip. He is the head of the ADHD psychiatric genetics GWAS analysis committee and an active member of the broader Psychiatric GWAS Consortium analysis committee, which is charged with analyzing all psychiatric data from these large-scale genome-wide association studies. He studied at the University of Chicago and Virginia Commonwealth University, earning a B.Sc. in genetics. He received his Ph.D. in human genetics from King's College in London.

Elizabeth A. Phelps (*Presenter*) is the Julius Silver professor of psychology and neural science at New York University. Previously, she served on the faculty of Yale University until 1999. Her laboratory conducts research on how the human brain processes emotion, particularly as it relates to learning, memory, and decision-making. She is the recipient of the 21st Century Scientist Award from the James S. McDonnell Foundation and a fellow of the American Association for the Advancement of Science and the American Academy of Arts and Sciences. She has served on the boards of directors of the Association for Psychological Science, Society for Neuroethics, and Society for Neuroeconomics; was the president of the Society for Neuroeconomics and the Association for Psychological Science; and served as the editor of the journal *Emotion*. She is the current president of the Society for Social and Affective Neuroscience. She received her Ph.D. from Princeton University.

Valerie Reyna (*Committee Member, National Academy of Medicine Member*) is professor of human development, director of the Human Neuroscience Institute, codirector of the Cornell University Magnetic Resonance Imaging Facility, and codirector of the Center for Behavioral Economics

and Decision Research. Her research integrates brain and behavioral approaches to understand and improve judgment, decision-making, and memory across the life span. She is a developer of fuzzy trace theory, a model of the relation between mental representations and decision-making widely applied in law, medicine, and public health. She is a fellow of the Society of Experimental Psychologists, the American Association for the Advancement of Science, several divisions of the American Psychological Association, and the Association for Psychological Science. She has been a visiting professor at the Mayo Clinic, a permanent member of study sections of the National Institutes of Health, and a member of advisory panels for the National Science Foundation, MacArthur Foundation, and National Academy of Sciences. She received her B.A. in psychology from Clark University and Ph.D. in experimental psychology, with qualifications in linguistics and in statistics, from Rockefeller University.

Paul Slovic (*Presenter*) is a professor of psychology at the University of Oregon and a founder and president of Decision Research. He studies human judgment, decision making, and the psychology of risk. His most recent work examines psychic numbing and the failure to respond to mass human tragedies. With colleagues worldwide, he has developed methods to describe risk perceptions and measure their impacts on individuals and society. He publishes extensively and serves as a consultant to industry and government. He is a past president of the Society for Risk Analysis and, in 1991, received its Distinguished Contribution Award. In 1993, he received the Distinguished Scientific Contribution Award from the American Psychological Association. In 1995 he received the Outstanding Contribution to Science Award from the Oregon Academy of Science. He has received honorary doctorates from the Stockholm School of Economics (1996) and the University of East Anglia (2005). He is a member of the National Academy of Sciences and the American Academy of Arts and Sciences. He holds a B.A. from Stanford University and an M.A and a Ph.D. from the University of Michigan.

Philip Tetlock (*Committee Member*) is a Canadian-American political science writer and is currently the Annenberg University professor at the University of Pennsylvania, where he is cross-appointed at the Wharton School and the School of Arts and Sciences. He is co-principal investigator of The Good Judgment Project, a multiyear study of the feasibility of improving the accuracy of probability judgments of high-stakes, real-world events. He has received awards from the American Psychological Association, American Political Science Association, American Association for the Advancement of Science, International Society of Political Psychology, American Academy of Arts and Sciences, and National Academy of Sciences. He has

published approximately 200 articles in peer-refereed journals and edited or written 10 books. His research programs have explored a variety of topics, including the challenges of assessing “good judgment” in both laboratory and real-world settings and the criteria that social scientists use in judging judgment and drawing normative conclusions about bias and error. He received his B.A. and M.S. from the University of British Columbia and Ph.D. in psychology from Yale University.

Jeremy Wolfe (*Presenter*) is professor of ophthalmology and radiology at Harvard Medical School and head of the Visual Attention Lab at Brigham and Women’s Hospital. He has extensive expertise in vision, binocular perception, visual attention, and cognitive science. His research focuses on visual search and visual attention with a particular interest in socially important search tasks in areas such as medical image perception (e.g., cancer screening), security (e.g., baggage screening), and intelligence. His work has developed the “guided search” model through several iterations. In recent years, he has become increasingly interested in the role of vision and attention in medical and security errors. He is editor-in-chief of *Cognitive Research: Principles and Implications*. He is president of the Federation of Associations in Behavioral and Brain Science and past chair of the board of the Psychonomic Society. He received an A.B. in psychology from Princeton University and a Ph.D. in psychology from the Massachusetts Institute of Technology.

