Public Meeting of the

President's Council of Advisors on Science and Technology (PCAST)

July 11, 2024

Meeting Minutes

Meeting Participants

PCAST Members

1. Frances Arnold, Co-Chair
2. Arati Prabhakar, Co-Chair
3. Maria T. Zuber, Co-Chair
4. Dan E. Arvizu
5. Dennis Assanis
6. John Banovetz
7. Frances Colón
8. Lisa A. Cooper
9. John O. Dabiri
10. William Dally
11. Sue Desmond-Hellmann
12. Inez Fung
13. Andrea Goldsmith
14. Laura H. Greene
15. Paula Hammond
16. Eric Horvitz
17. Joe Kiani
18. Jon Levin
19. Steve Pacala
20. Saul Perlmutter
21. William Press
22. Jennifer Richeson
23. Vicki Sato
24. Lisa Su
25. Kathryn Sullivan
26. Terence Tao
27. Phil Venables
28. Catherine Woteki

PCAST Staff

1. Lara Campbell, Executive Director
2. Melissa A. Edwards, Deputy Executive Director
3. Reba Bandyopadhyay, Deputy Executive Director for Research and Workforce
4. Bich-Thuy (Twee) Sim, Assistant Director for Transformative Medicine and Health Innovation
5. Sachin Shah, Policy Analyst
6. Siima Machayo, Intern

Invited Speakers (in order of presentation)

1. Idowu Jola Ajibade, Associate Professor of Environmental Sciences, Emory University
2. Amy McGovern, Lloyd G. and Joyce Austin Presidential Professor of Computer Science and Meteorology, University of Oklahoma

3. Dawn Wright, Chief Scientist, Environmental Systems Research Institute
4. William Anderegg, Professor of Biological Sciences, University of Utah
5. Marina Vance, Associate Professor of Mechanical Engineering and McLagan Family Faculty Fellow, University of Colorado, Boulder
6. Muyinatu Bell, John C. Malone Associate Professor of Electrical and Computer Engineering, Johns Hopkins University

START DATE AND TIME: THURSDAY, JULY 11, 2024, 10:00 AM Eastern Time

LOCATION: Virtual Meeting via Zoom.gov

WELCOME

PCAST Co-chairs: Frances Arnold, Arati Prabhakar, Maria Zuber

The PCAST co-chairs called the meeting to order – Frances Arnold, California Institute of Technology; Arati Prabhakar, Science Advisor to the President; and Maria Zuber, Massachusetts Institute of Technology. Arnold stated that the two sessions on the future of research continues PCAST's exploration of this topic that includes the discussion on the national purpose of research and emerging university research models discussed at the May 22, 2024 PCAST meeting. One trend noted at the May meeting was an increase in research seeking to address societal challenges.

SESSION: RESEARCH WITH SOCIETAL IMPACTS: CLIMATE RESILIENCE

IDOWU JOLA AJIBADE

Ajibade spoke about convergence research as a bedrock advancement in climate change resilience. Building resilience to climate change, she said, requires having multiple perspectives, expertise, and methods since no single disciplinary approach can address this issue alone. Convergence research aims to bring together experts from the social sciences, humanities, and science, technology, engineering, and mathematics (STEM) to develop innovative solutions with social impact that would translate to meaningful change for society, health, and the environment. Convergence science, she added, must also address epistemic inequities often seen in interdisciplinary research and be conducted in a way that does not prioritize a particular discipline, especially the natural sciences, and respects everyone participating in the research project.

Ajibade said that data does not change society, people do, which is why bringing people together to advocate for policy change is when policy changes begin to happen. In the same way, artificial intelligence (AI) will not be the technology that saves society.

There are three important questions regarding convergence research, said Ajibade:

- Why is siloed research a problem?
- How does one conduct convergence research?

- How does one gauge the impact of one's research?

The problem with siloed science is that it prioritizes particular ways of knowing and creates a hierarchical way in which society implements knowledge according to a largely Eurocentric world view. This type of knowledge production, said Ajibade, maintains a White framework that normalizes racial inequality and racial superiority in the way researchers conduct science. The resulting knowledge, she said, is often good at hammering data without it producing change that matters in society.

Ajibade said science is largely rooted in power relations and a historical and social context. Failing to recognize this fails to democratize decision making and will fail to reduce inequalities, something that is important for addressing climate change. In that respect, she said it important to think about the intersection of decision making, the social context of a decision, and reducing inequality in society. She also noted that prioritizing the hard-science aspect of climate change and thinking about it solely as a greenhouse gas issue misses many perspectives such as energy justice, social justice, or housing.

Convergence research, said Ajibade, not only brings together multiple perspectives, but it also addresses the social processes and structural biases that have been built over the centuries into knowledge production. It tackles the challenge of diversity and inclusion in STEM, decenters coloniality from knowledge frameworks, and embraces intentionally disruptive approaches in research to advance knowledge and change society.

Ajibade noted the need to invest more heavily in the social sciences because that is where she believes the solutions to climate resilience lie. She said that if data from the natural sciences alone could address climate change, things would have changed and been transformed, but that is not what is happening because people and policies are involved. Investing in the social sciences will enable thinking about the psychology of climate change and resilience.

In a convergent science project she conducted, Ajibade wanted to understand how to create equitable resilience in addressing cascading climate-related disasters. This work prioritizes the community's perspective and examines social vulnerability and baseline resilience factors that lead to some community's being more vulnerable to the adverse effects of climate change and others to be more resilient. One finding was that the participants acknowledged that government alone will not address the problems resulting from climate change, that people will need to work together to find solutions.

Ajibade highlighted research that mapped heat in Maricopa County, AZ, and identified that mobile homes were hotspots and the reason was that landlords were denying tenants the ability to install air conditioning. The lead researcher worked with community-based organizations and policymakers to pass a bill that prohibits landlords from denying tenants the opportunity to install life-saving air conditioning in their mobile homes.

AMY MCGOVERN

McGovern discussed building trustworthy AI for weather and climate applications. Trustworthy AI, she said, can provide timely, reliable, and actionable information to decision makers. Using AI to improve weather prediction at all time scales can save lives, protect property and crops, provide personalized risk management, and improve societal climate resilience. She noted that in 2023, there were 28 billion dollars' worth of weather and climate disasters that affected the United States. While AI cannot change

the weather, it can better predict when and where severe weather events will occur and enable communities to better prepare for them.

With her colleagues at the National Science Foundation (NSF) AI Institute for Research on Trustworthy AI in Weather, Climate, and Coastal Oceanography (AI2ES), McGovern is developing novel AI techniques based on the laws of physics it can demonstrate are trustworthy. This entails working on understanding the nature of trust among end uses of the technology so the tools they develop are trustworthy. AI2ES, she added, is focused on improving prediction, understanding, and communication of high-impact weather to improve climate resiliency, and its approach is an example of convergence research.

McGovern said AI for earth science has different needs than traditional AI because it requires using physics-based methods, rather than learning from a series of images, to understand the spatial-temporal context of weather forecasting and be useful for making life-and-death decisions. AI2ES's goals are to develop explainable AI and interpretable methods aligned with earth science needs, develop physics-based AI techniques, develop robust AI prediction techniques, use trustworthy AI to provide actionable information to diverse users, and enhance scientific and physical understanding of basic processes through trustworthy AI. Topics of study include winter weather, sub-seasonal prediction of tropical cyclones, and features of coastal oceanography, including fog and saving sea turtles.

The key to this being convergence research, said McGovern, is including social scientists who are working with end users, AI researchers, and atmospheric scientists to understand what it means to make trustworthy AI. Their findings inform the work of AI developers as they create explainable AI techniques. McGovern said weather forecasting is on the cusp of an AI revolution that stands to dramatically improve forecast accuracy. An interesting feature of this impending revolution is that it is being driven by private industry, not academia.

In closing, McGovern said her vision is for there to be a multiagency, multisector transdisciplinary weather forecasting center that includes academia, government, private industry, and nongovernmental organizations and integrates the social sciences in its work. She noted this is something that PCAST issued a report on in the past, but nothing has made it a reality.

DAWN WRIGHT

Geography, said Wright, is the ultimate interdisciplinary endeavor and one that often follows the mandate of use-inspired science to develop equitable solutions to the world's biggest problems. The geographic approach—a way of thinking and problem solving that integrates and supports powerful digital methodologies. These methodologies include geoanalytics for creating insights and understanding through spatial data science; geovisualization, a language through maps and visualization for communicating the content and the context of our world; geodesign, scenario building for creating sustainable and inclusive futures including via digital twins; geocollaboration, for engaging as many communities as possible; and geoaccounting, to account for all the factors while setting up balanced measures driven by shared values.

In its research, Wright's organization aims this geographic approach at the global geospatial framework now emerging and involves a host of globally interconnected sensors and data sets and thousands of organizations seeking to share data sets and services, especially by way of geographic information

systems. This spatial orientation is special because spatial considerations lie at the heart of important issues such as where to address hotspots of ocean overheating, poor ocean health, or threatened biodiversity; identifying where climate hazards are forcing people to live, work, and shop, and understanding where to ensure resilient supplies of fresh water.

Wright discussed the Group on Earth Observations Global Water Sustainability (GEOGLOWS) partnership that is using geoanalytics and geoaccounting to provide a global accounting of freshwater. This is a non-traditional collaboration with universities, nonprofit organizations, and government that she said is an example of a modernized public-private partnership. GEOGLOWS provides a up to 10 days of forecasting for seven million streams globally that local to national governments and other organizations can use to mitigate risks from flooding and for irrigation planning, hydroelectric dam management, transportation logistics and commerce for barges and ferries, and recreation planning for tour boats, paddle sports, fishing, and more.

GEOGLOWS, said Wright, delivers actionable data and web services on a daily and weekly basis for free to places where little to no resources exist. It also empowers locally adaptable open-source code and web application to fill important data gaps and strengthen water resilience efforts. Filling those data gaps provides information back into the hydrologic data science to inform the next version of GEOGLOWS.

Wright said her organization has partnered with the White House, the National Oceanographic and Atmospheric Administration (NOAA), National Aeronautics and Space Administration (NASA), Departments of the Interior and Energy, and the U.S. Global Change Research Program to develop the Climate Mapping for Resilience and Adaptation portal. The portal has geovisualization, geocollaboration, and geoanalytic tools that enable climate mapping for resilience. This use-inspired research produced a dashboard of maps and statistics to visualize what is happening in terms of real-time risks to people, property, and infrastructure from wildfires, coastal and inland flooding, extreme heat, and drought. The dashboard also provides the ability to examine what the future exposure to weather-related events will be within a location of interest based on either high- or low-emission scenarios. The maps can calculate if a community is eligible for priority federal funding through the Justice40 initiative that aims to ensure that 40 percent of funding goes to communities that are marginalized, underserved, and overburdened by population.

ARNOLD MODERATED THE Q&A AND DISCUSSION BETWEEN PCAST MEMBERS AND AJIBADE, MCGOVERN, AND WRIGHT

SESSION: DISCUSS AND VOTE ON EXPANDING STEM TALENT IN THE FEDERAL WORKFORCE LETTER

Arnold introduced the session by noting that most PCAST reports have included a discussion of the need for STEM talent in areas. The letter under discussion focuses on addressing the federal government's need for STEM talent to enable many activities essential to the effective functioning of the government. While there are agencies that clearly require technical expertise, every agency has information technology and increasingly AI efforts that require a STEM workforce.

DAN ARVIZU

Arvizu presented the findings of the PCAST Federal STEM Working Group. They included:

- The federal workforce is aging. In 2020, the Partnership for Public Service found that only 7 percent of the federal workforce was under the age of 30. In 2022, the White House found that 15 percent of the Federal workforce was eligible to retire, rising to 30 percent over the subsequent five years.
- STEM-skilled talent needed goes well beyond so-called "STEM agencies."
- Multiple reports have outlined the challenges in Federal recruitment and human resources management, and continued follow-up on the recommendations in these reports is needed to meet future missions.
- National Security agencies are usually more proactive in addressing STEM talent recruiting.
- Included among the highest priority issues are:
    - The slowness and complexity of federal hiring, not just for STEM.
    - Differentiating and professionalizing STEM marketing and recruiting, including segmenting the different type of employee assignments, early career civil servants, tour of duty and temporary roles for seasoned professionals, and other internships and special purpose hiring programs.
    - Strategically managing the use of special authorities regarding conflict of interest provisions.
- Several pilot programs, including the Office of Personnel Management's (OPM) Pathways Program; U.S. Digital Service (USDS); and the Executive Order on AI, provide useful models for change. While encouraging, these programs are insufficient in scale and scope to make a major contribution to increasing STEM talent in government.
- Adopting novel and skills-based hiring approaches such as pooled hiring and subject matter expert qualification assessments (SME-QA) appear promising.

Arvizu explained that SME-QA is an approach that requires a partnership between subject matter experts and human capital offices to define an agency's needs and be able to better recognize the talent that will fill those needs effectively. He noted that many respondents the working group spoke with urged PCAST to sound a clarion call regarding the need to improve STEM talent recruitment into the federal government.

The working group made six recommendations, which Arvizu discussed briefly.

1. Expeditiously adopt initiatives that have been piloted by OPM, including leveraging the processes developed for the AI surge, and maximize the use of existing hiring flexibilities at scale across all agencies.
2. Modernize recruiting and accelerate hiring processes. Differentiating and professionalizing STEM marketing and recruiting, and upskilling agency human resources offices through training or embeds from OPM or USDS, will enhance the effectiveness of these efforts. Consideration should be given to "pooled hiring" approaches and the use of the SME-QA hiring process.

3. Agencies should ambitiously expand use of the Pathways program and the expedited hiring path it offers to expand pre-qualified candidate pools. Leverage the NSF and Department of Commerce regional innovation hubs to develop internships that introduce students at all levels to federal job opportunities that mirror the expertise they gain in the hub setting.
4. Lower barriers to bringing on seasoned experts for "tours of duty," leveraging the less onerous conflict of interest mitigation approaches used in some defense-related agencies.
5. Designate a senior or executive leader at each agency to identify and reduce headwinds to progress, partnering with OPM, agency human resources, and other stakeholders as needed. These leaders should report to the agency head within 90 days of assignment.
6. Direct OPM to create a repository to share successful initiatives and best practices government wide.

As to who these recommendations are addressed, Arvizu suggested they could lead to an Executive Order that sets expectations for each agency regarding their hiring plans. This is a topic of great interest that needs attention from an agency's highest level personnel and that each agency needs to show it is employing best practices to increase their STEM recruitment.

ARNOLD MODERATED THE Q&A AND DISCUSSION BETWEEN PCAST MEMBERS AND ARVIZU

Arnold reminded the meeting participants that the rapid rate of change in science is much faster than the rate of change in the federal government. This is why the federal government is so behind in hiring STEM talent and why it needs a revitalization to attract a younger cohort of STEM talent.

Maria Zuber noted the working group found that agencies have the authority to accelerate hiring and some agencies use that authority on a regular, ongoing basis. She asked if the working group thought about how to incentivize those agencies not using that authority to do so. Arvizu replied that each agency looks at hiring in its own way and some find the complexity of the hiring process to be a barrier. He explained that the number of specific authorities is in the hundreds, with some specific to a particular agency or section of an agency and specific conditions. When asked about the barriers to rationalizing those authorities, Arvizu said one of the recommendations aims to make it clear to the agencies how to use these authorities by spelling out exactly when they use them. However, a cultural barrier in some agencies can lead to existing rank and file resenting the fact that these authorities can circumvent the rules and restrictions they had to deal with when they were hired.

Arvizu said agencies need to realize that the hiring landscape is evolving and now there is a need for more STEM professionals, not fewer. Agencies also need to consider competency-based hiring as opposed to credential-based hiring. He noted there are roles that people can take that are STEM-related but do not require the credentials that the federal government seeks occasionally.

William Dally commented that the letter mentions that federal pay scales do not reflect the market for STEM talent, particularly in computer science and AI. He pointed to the need for creative approaches to addressing this problem, whether that involves creating an additional pay scale that allows agencies to pay market rates for those people. Today, agencies get around this to some extent by using federally funded research and development centers and contractors, but that approach has its limits given the demand for STEM talent in the federal government. It is important, said Dally, to

align the federal government with the marketplace to attract the high-quality talent needed to lead the United States. Arvizu replied that some authorities provide more latitude in deciding salaries, but it will be important to capture people's passion and show them the federal government is an attractive place to work so they might accept a lower salary than the private sector would offer them.

Sue Desmond-Hellman asked about the importance of retaining STEM employees in the federal workforce. Arvizu replied that he sees retention as a matter of making the culture of an organization so attractive that people want to stay. He cited NASA and NOAA as examples of federal agencies with such a culture, particularly regarding the idea that the people working at those agencies feel they are making a difference. In terms of recruiting employees, Zuber noted that some agencies have a reputation as being a great early place to work early in one's career because they serve as springboards to higher-paying opportunities in the private sector.

Vicki Sato asked if agencies could winnow or eliminate many of the hiring requirements currently on the books. Arvizu replied he believes agencies have the authority to do more than they do in that regard. As to whether an agency can simply wipe the slate clean and rationalize their hiring processes, Arvizu said that the working group concluded the answer would depend on the specific agency and position, which is why it recommended that every agency should evaluate its specific needs. Some agencies, he noted, would experience pushback internally if there was too much innovation in hiring. Phil Venables noted that the executive leaders of the Department of Defense and the intelligence community have taken personal responsibility for driving new workforce development approaches, thereby providing cover for when their hiring teams redefine some of their authorities.

Arvizu said the Defense Department sponsors internships and early vetting as a recruiting tool. The letter highlights how the Defense Department fills its needs in its civilian workforce and points to a new program—Classified Ready Employment Workforce—that reads sophomores into private sector programs in the defense industry. When they graduate with their degree, they will already have a security clearance, which greatly speeds the hiring process.

Catherine Woteki asked Arvizu to expand on the recommendation for agencies to identify a hiring champion. Arvizu said the idea is to have one person who is accountable for looking at the hiring process in an agency given its mission and needs and who reports to the agency's executive leadership. Venables said some agencies have done this and found it effective, whether that person is the head of human resources or someone on the broader leadership team who partners with the head of human resources.

With the discussion concluded, PCAST voted unanimously to accept the letter to the President on building the federal STEM workforce.

SESSION: RESEARCH AND RESEARCHERS ON THE HORIZON

Zuber introduced the session by noting that significant new factors affect research today, including higher salaries for graduate students and postdoctoral researchers, higher laboratory material and

equipment costs, increased compliance demands to thwart nefarious foreign influences, and ubiquity of AI, among others. While some of these factors are positive, they all increase the cost and complexity of doing research when federal funding has been flat or declining, with no relief in sight. She also pointed to the increased recognition of the value and opportunities associated with interdisciplinary research but also the limited paths to support or publish such research.

Zuber then introduced the speakers, who serve as examples of researchers successfully navigating exciting paths in their research careers.

WILLIAM ANDEREGG

Anderegg said Earth's forests provide tremendous benefits to society and are slowing the pace of climate change, taking up about 25 percent of the carbon that humans emit into the atmosphere each year. There is enormous uncertainty about the future of Earth's forests, raising the key question of whether they will continue to be major carbon sinks over the 21st century?

Earth's forests, said Anderegg, are perched on a knife's edge between two opposing sets of forces. On one hand, the benefits of rising carbon dioxide in the atmosphere can help plants photosynthesize more, grow more, and potentially maintain or expand the carbon sink over the 21st century. On the other hand, the stresses of climate change, including rising temperatures, drought, wildfires, and pests and pathogens can overwhelm the benefits of elevated carbon dioxide levels and drive mass forest die off, which would release carbon into the atmosphere, flipping the Earth's ecosystems and forests from a carbon sink to a carbon source. It is unclear, he said, when and where each mechanism dominates.

His research focuses on developing a multiscale understanding of the physiological response of plants, from the cellular to the organismal level, as they respond to water stress, increasing carbon dioxide levels, and other climate-related drivers. He then uses a variety of approaches to scale that understanding to the ecosystem level to determine how species interact and compete for resources. A newer piece of his research is trying to translate this physiological and ecological understanding to inform policy making around forests as nature-based climate solutions. Earth's forests, said Anderegg, have the potential to account for 10 to 15 percent of the greenhouse gas reductions needed to stabilize Earth's climate.

In general, said Anderegg, forest climate solution projects must have a net cooling effect on the climate, lead to additional carbon storage, account for shifting activities outside of a projection's boundaries, and address risks to durability of these effects in the face of wildfires and droughts. Currently, he added, there are enormous problems in existing carbon offset protocols in each of these four areas, making this a crucial research frontier at the nexus of science and policy.

Anderegg and his colleagues are trying to build maps, tools, and projections of climate risk in U.S. and global forests. Modeling projects that wildfires will increase dramatically in the western United States, while drought and climate stress increase substantially in the Southwest. Modeling also suggests insect-driven tree mortality will increase, particularly along the West Coast. Different models produce large differences in terms of whether U.S. forests will absorb or release more carbon than they do today. The most realistic result, he said, is where carbon losses occur in the U.S. West

and carbon gains occur in the U.S. Northeast and Northwest. Modeling also suggests that current forest offset projects in California are at substantial risk of losing carbon. As a next step, Anderegg and his colleagues are leveraging satellite, ground plot, and machine learning methods to develop U.S. and global reversal risk and buffer pool sizes needed for forest climate protocols and policies.

In conclusion, said Anderegg, interdisciplinary funding from federal agencies, including NSF, and foundations have been instrumental for this work, particularly what he called "blue sky thinking" funding for taking risks. Carving out the time for deep thinking and creativity in research is crucial and a challenge given the rising costs of research and the increasing amount of time that he and others are spending on compliance and administrative issues. Finally, as in many other spaces such as AI, open science is critical, with a large risk arising from many of the models and data being developed in the private sector. This limits confidence in the results, transparency, and accountability.

MARINA VANCE

Vance discussed her work on emissions, dynamics, and personal exposure to indoor fine particulate matter, also known as $PM_{2.5}$ or aerosols. Fine particulate matter, she said, is the world's leading environmental risk factor responsible for over eight million deaths worldwide annually. Fine particulate matter exacerbates cardiovascular and respiratory issues; is tied to brain aging, anxiety, and depression, and is the most widespread environmental carcinogen. Children's test scores are lower, she added, when their schools are located closer to highways, and data from six U.S. cities shows a clear relationship between increasing concentrations of fine particulate matter and the number of people dying. She noted that though monitoring stations record fine particulate matter levels outdoors, people are still exposed to high concentrations indoors.

There is a continued need, said Vance, to understand chemical and physical processes in indoor environments, where most people spend some 90 percent of their time. Though making buildings airtight is good for energy consumption and lowers the penetration of outdoor pollutants, it can increase exposure to some indoor sources, making it imperative to understand the indoor environment and the outdoor environment. Moreover, indoor chemical and physical processes are likely to differ from outdoor process, with different sources, different surfaces, and closer proximity to those indoor sources. There are also different oxidizers indoors, with less sunlight, more chemical cleaners, and more combustion.

Vance said the goal of her research is to study emissions, transport, and fate of particulate matter and the gaseous components of indoor air pollution to generate information that the public and decision makers can use to make informed decisions to reduce people's exposure to particulate matter. One project, called HOMEChem, took place in the summer of 2018 involved over 20 research groups at 13 universities in the United States and Canada, five industry partners, and government agencies. It focused on cooking, cleaning, human occupancy, and the use of personal care products and has produced 36 peer-reviewed publications to date. HOMEChem, said Vance, has been transformational in establishing the field of indoor environmental chemistry. The second study, run in the spring of 2022, involved over 14 researcher groups from 12 universities and the National Institute of Standards and Technology. It examined the effect of controlled additions of products and compounds, including wildfire smoke and aerosols generated during cooking. That project has produced five peer-reviewed papers to date. All told, the two projects costs a few million dollars of funding, excluding instrumentation costs.

Vance said she has been privileged to receive funding from sources such as the Environmental Protection Agency and NSF, but those were single principal investigator grants. Conducting large, collaborative projects required funding from the Alfred P. Sloan Foundation, but its program on the chemistry of indoor environments is ending in 2024. What is missing in the field of indoor air quality, she said, is a deeper tie between the aerosol science, environmental engineering, and health research fields. For example, there have been no epidemiological studies on indoor air pollution. Vance also noted the challenge of keeping a relatively small research group going given funding uncertainties and the difficulty recruiting talent for Ph.D. studies because of the changed culture of graduate school following the COVID-19 pandemic. Other issues include navigating the mismatch between 3-year funding cycles and five-plus year Ph.D. cycles and planning and redistributing funds to cover graduate student salary increases and inflation.

MUYINATU BELL

Bell discussed her work using theory, models, and simulations to develop equitable medical imaging systems such as beamforming, a signal processing technique that relies on the complex math and physics of sound propagation to determine how images will be created. Her group also designs imaging probes that will improve ultrasound and photoacoustic image quality. She noted she can interface her designs with commercially available hardware to create new systems to test in humans. This research is exciting, she said, because it allows her to consider all possible patients in its designs, which might produce new knowledge from clinical studies that would lead to innovation.

After explaining the basic principles of beamforming for ultrasound and photoacoustic imaging, Bell discussed how she addressed noise or clutter in images by inventing the concept of coherence-based beamforming, when she was a graduate student. This new technique produces sharper images of a beating heart, which is important for diagnosing the cardiovascular health of an individual, particularly for overweight or obese patients whose multiple tissue layers generate more acoustic noise. More recently, she has shown she can use this same principle to distinguish between fluid and solid masses. This has proven useful in distinguishing between fluid breast masses, which are typically benign but may trigger an unnecessary biopsy. This is particularly promising for women with dense breast tissue who represent an underserved population regarding medical imaging techniques to non-invasively detect breast cancer.

Bell said photoacoustic imaging, which uses light to trigger acoustic emissions, suffers from limits to the depth with which light can penetrate through tissues. This is a particular problem for darker-skinned individuals because of melanin's light absorption properties. However, coherence-based beamforming can overcome the problem of acoustic scattering arising from melanin absorbers. She is now looking to apply this concept to the emerging area of flexible array technology that will allow wearable health applications to conform to different body shapes and sizes. Her team has adapted this technique to visualize tooltips for surgical and interventional guidance applications.

In conclusion, Bell said diversity drives innovation, both in terms of the diversity of ideas and datasets and the diversity of the research team. She noted that she usually ignores disciplinary silos when innovating new ideas, but she is well aware that she needs to introduce these boundaries when writing grants and publishing papers to make the concepts more palatable to a particular community.

ZUBER MODERATED THE Q&A AND DISCUSSION BETWEEN PCAST MEMBERS AND ANDEREGG, VANCE, AND BELL

PUBLIC COMMENT

No public comments were presented.

CLOSING COMMENTS

Zuber and Arnold concluded the meeting by thanking the speakers for sharing their experiences.

MEETING ADJOURNED: 2:55 PM Eastern Time

I hereby certify that, to the best of my knowledge, the foregoing minutes are accurate and complete.

Frances Arnold, Ph.D.
Co-Chair
President's Council of Advisors on Science and Technology

Arati Prabhakar, Ph.D.
Co-Chair
President's Council of Advisors on Science and Technology

Maria Zuber, Ph.D.
Co-Chair
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