Trans-NIH Research Opportunities in the Basic Behavioral and Social Sciences

National Institutes of Health Council of Councils Working Group Report

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Executive Summary

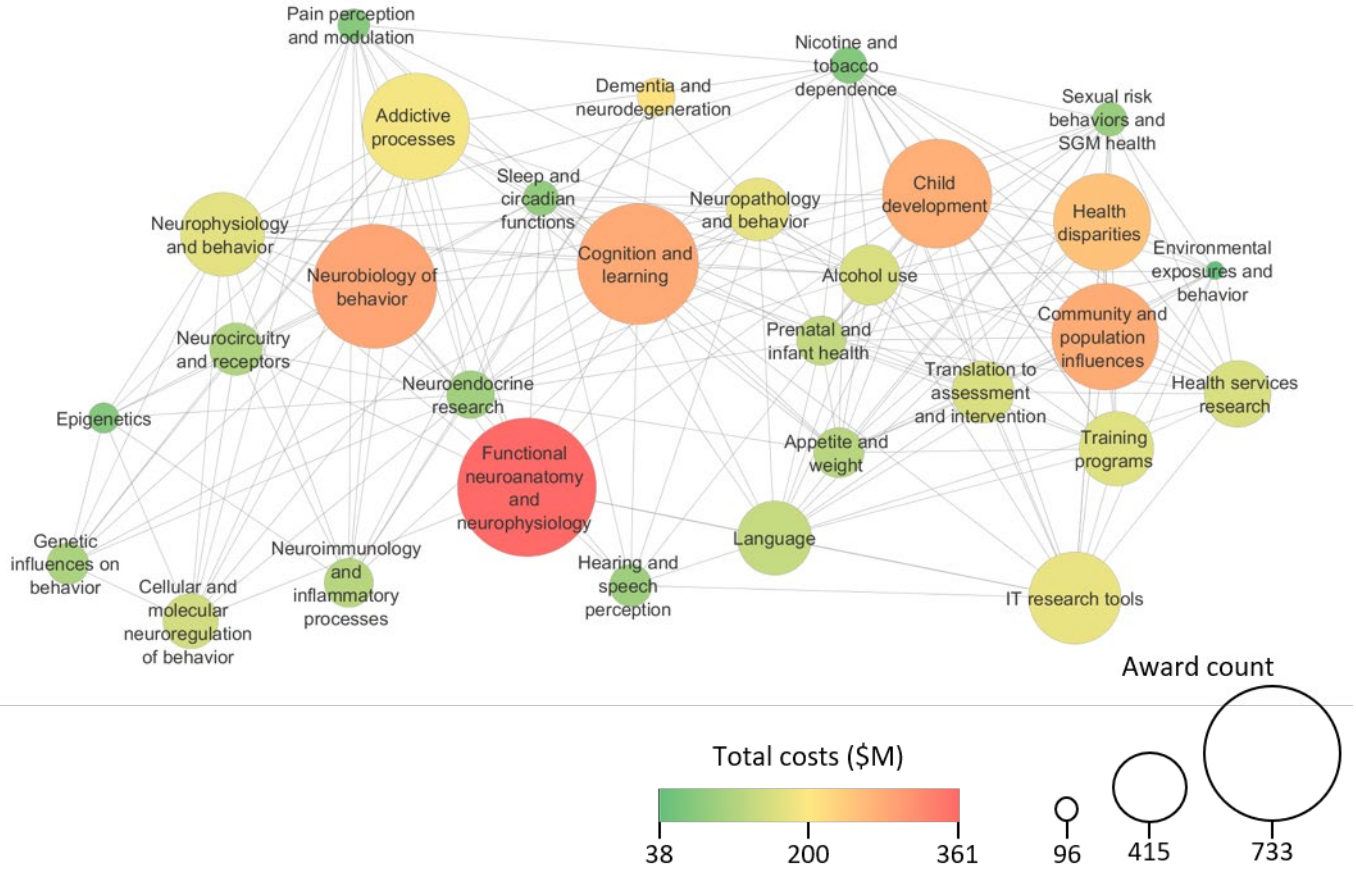
COVID-19 transmission, structural racism, health disparities, firearm violence, and opioid addiction are among the urgent public health issues that are predominantly social and behavioral in nature. Effectively addressing these issues requires a robust basic behavioral and social sciences research (bBSSR) agenda that can support new and innovative approaches to understanding and changing behavior and social systems. A working group of the National Institutes of Health (NIH) Council of Councils was established to identify promising and emerging areas of bBSSR relevant to the NIH mission, determine which of these areas of research are not adequately supported by current NIH investments, and examine if these research needs can be addressed by individual Institutes and Centers (ICs) or require trans-NIH efforts to accomplish.

Behavioral and social sciences research (BSSR) at the NIH involves the systematic study of behavioral and social phenomena relevant to health, and bBSSR furthers the understanding of fundamental mechanisms and patterns of behavior and social functioning. The NIH has a long-standing commitment to health-related basic or foundational research, and the NIH-Wide Strategic Plan specifies that fundamental science includes bBSSR that generates knowledge of how living systems interact with and are influenced by experiences at the individual, family, social, organizational, and environmental levels.[1] The bBSSR that the NIH supports is broad and varied, and it includes the study of a range of core research areas including behavioral, cognitive, and social neuroscience; cognitive processes such as attention, learning, and memory; developmental processes; social systems; and epidemiology and population health.

Following an earlier Advisory Committee to the Director (ACD) working group report[2] on this research area in 2004 and the establishment of the Basic Behavioral and Social Sciences Opportunity Network (OppNet; oppnet.nih.gov) in 2009, the NIH investment in bBSSR (competitive Type 1 and 2 Research Project Grants) remained relatively flat (at approximately $250 million to $300 million) from fiscal year (FY) 2008 through FY 2014. From FY 2014 through FY 2019, however, bBSSR funding doubled, reaching $652 million in 2019. NIH extramural funding support overall increased by 30 percent during this time. NIH support for bBSSR resides predominantly in seven ICs: the National Institute of Mental Health (NIMH), the *Eunice Kennedy Shriver* National Institute of Child Health and Human Development (NICHD), the National Institute on Drug Abuse (NIDA), the National Institute on Aging (NIA), the National Institute of Neurological Disorders and Stroke (NINDS), the National Institute on Alcohol Abuse and Alcoholism (NIAAA), and the National Institute on Deafness and Other Communication Disorders (NIDCD), although all NIH ICs have some investment in bBSSR.

To identify and understand the scope of bBSSR-coded, NIH-funded projects, the Office of Portfolio Analysis (OPA) performed natural language processing analyses (word2vec$_{OPA}$) on the bBSSR portfolio from FY 2008 through FY 2019 and identified 30 coherent and interrelated clusters of bBSSR. Figure 1 displays these clusters with the size of the circles representing the number of awards and the color of the circles

Figure 1. NIH investment by topic area (FY2008-FY2019)



Key: *IT = information technology; SGM = sexual and gender minority*

representing the total funding for these awards. The larger bBSSR clusters were functional neuroanatomy and neurophysiology, neurobiology of behavior, cognition and learning, child development, addictive processes, and community and population influences. The bBSSR clusters with fewer awards included environmental exposures and behavior, epigenetics, pain perception and modulation, sexual risk behaviors and sexual and gender minority (SGM) health, and sleep and circadian functions. The analysis also demonstrated that NIH-supported bBSSR overlaps considerably with several other areas, particularly neuroscience. A review of Research, Condition, and Disease Categorization (RCDC) System codes for both terms indicated that 62.1 percent of bBSSR awards also are coded as neuroscience whereas only 15.1 percent of neuroscience awards are coded as bBSSR.

The working group considered and discussed analyses of the NIH bBSSR portfolio conducted by OPA; considered emerging, promising, and understudied areas of bBSSR; and systematically obtained input from NIH program officers to address the three questions of its charge:

1. What are the promising and emerging areas of bBSSR that are priorities for NIH support (i.e., have a plausible translational pathway to health-relevant applied research, not supported under the mission of another funding agency)?
2. Which of these emerging areas of research are not adequately supported by the current NIH bBSSR portfolio?
3. Can these inadequately addressed emerging areas of research be addressed by individual IC efforts or do some require a trans-NIH effort to address?

What are the promising and emerging areas of bBSSR that are not adequately supported by the NIH?

The working group identified a number of emerging and promising areas of bBSSR that do not appear to be adequately supported by the NIH (questions 1 and 2 of the charge). In the context of increasing NIH support for bBSSR over the past few years, the relatively small current level of support for many of these promising areas suggests the need for a reprioritization of the bBSSR portfolio to provide additional support for these areas of research while maintaining strong NIH support for the core areas of bBSSR. The following are recommended as bBSSR research areas that the NIH should consider strengthening.

1. *Behavioral, cognitive, and social neuroscience*. bBSSR is substantially integrated with neuroscience at the NIH, but the working group identified three specific areas of promising research that the NIH should pursue:
    1.1. More research on event representations in perception, learning, and memory, including developmental process and the application of computational neuroscience techniques to understand better how specific experiences “get into the brain.”
    1.2. Greater focus on understudied regions of the brain (e.g., the cerebellum) and the role of these regions on behavior.
    1.3. Increased integration of how behavior and social environments are embodied both in the brain and the periphery, and how the brain and these other organ systems interact in the process of embodying experiences.
2. *Epigenetics.* Epigenetics is one of the smaller clusters of NIH-supported bBSSR, but it also is one of the most influential from a publication and citation perspective. Genetic, molecular, and cellular research in epigenetics and gene regulation needs to be integrated better with bBSSR and expanded to consider the behavioral and social phenomena that influence epigenetic and gene regulatory processes.
3. *Basic functions of sleep and sex.* Sleep and sex are basic human and animal functions but are underrepresented in the bBSSR portfolio of the NIH. Basic research on behavioral and social mechanisms and processes involved with sleep and sexual function can generate foundational knowledge that can be extended to a range of related topics in health, well-being, illness, and treatment. Strengthening

trans-NIH support for bBSSR in sleep and sexual functions, including the health of SGM individuals, is needed.

4. *Infectious disease–related basic behavioral and social processes.* The COVID-19 pandemic starkly illustrated the uncertainty in mitigating transmission with inadequate basic research on how social and behavioral processes influence infectious disease control and mitigation behaviors by individuals and groups. It is a public health imperative that the NIH build a stronger bBSSR portfolio in infectious disease–related behaviors to be better prepared for future epidemics.
5. *Social interactions and influences on health.* The current NIH bBSSR portfolio focuses predominately on the individual and, to a lesser extent, broader social units such as schools, workplaces, and communities. The social interactions and networks that connect individuals with the social units, however, appear understudied. OppNet recently released a program announcement on social connectedness and isolation on health (PAR-21-144; https://grants.nih.gov/grants/guide/pa-files/PAR-21-144.html), but more research is needed on the influence of dyads, families, and small group interactions and networks on health.
6. *Maintaining behavior change.* Most bBSSR relevant to behavior change has focused on the mechanisms that initiate change, less so on the mechanisms that maintain behavior change. Basic processes, such as the transition from goal-directed to habitual learning, implicit learning, and the social and environmental context that supports maintenance of behavior, need more in-depth study.
7. *Positive health processes*. The NIH mission understandably leads to a focus on illness processes. Health processes, however, are not merely the absence of illness processes, and greater attention to the basic processes that influence gradations of health and wellness appears needed. Such research also has the potential to improve our understanding of susceptibility and resilience to illness.
8. *The science of science.* The conduct of research supported by the NIH faces many challenges that are social and behavioral in nature, such as trust in science, decision-making under uncertainty, ethical and privacy concerns, recruitment and retention, and the effects of science policies. bBSSR in areas such as altruism, trust, persuasion, decision-making, and incentive structures are highly relevant to conducting biomedical and behavioral and social sciences research ethically and efficiently. There appear to be pockets of research at NIH that focus on the science of science, but a more concerted trans-NIH effort appears warranted to translate basic findings relevant to the conduct of research and how research is communicated to the public.

Can these inadequately addressed emerging areas of research be addressed by individual IC efforts or do some require a trans-NIH effort to address?

Addressing this question required a comprehensive perspective not only of the promising areas identified above but also of the NIH bBSSR portfolio more generally. This more comprehensive perspective included considerations of workforce diversity and capacity building, as well as the infrastructure and scientific process needs of the entire bBSSR portfolio.

1. *Increase workforce diversity.* The NIH has created a number of programs to strengthen and diversify the health research workforce, most recently with its UNITE Initiative (https://www.nih.gov/ending-structural-racism/unite). The working group strongly endorses NIH efforts to produce a more diverse and inclusive workforce and encourages the NIH to draw from considerable basic research on structural and cultural racism to develop an empirically-based approach to addressing scientific workforce diversity.

   The behavioral and social sciences have been leaders in diversifying the gender and race/ethnicity of the scientific workforce. More women than men are in the behavioral and social sciences, with the exception of economics and political science.[3] The behavioral and social sciences need to continue to make strides in advancing underrepresented minorities (URMs) in the scientific workforce, but a recent National Science Foundation (NSF) study shows that the percentage of URMs in psychology and the social sciences has had the largest increase among scientific disciplines, increasing from 11 percent in 2003 to nearly 20 percent in 2017.[4]

   As a result of the strides made in workforce diversity by the behavioral and social sciences, one potential byproduct of a more robust bBSSR agenda at the NIH is increasing the diversity of the overall scientific workforce supported by the NIH. NIH researchers[5] showed that African American/Black (AA/B) investigators are represented more in research areas that include substantial bBSSR such as health disparities and community health influences. An OPA analysis of bBSSR clusters by URMs revealed a significantly higher proportion of AA/B applicants, relative to AA/B applicants across the bBSSR portfolio, in training programs and areas related to health disparities, sexual risk behaviors and SGM health, health services research, and child development. A number of bBSSR clusters, however, have very low proportions of URM principal investigators, and programs to encourage greater workforce diversity in these areas of bBSSR are needed.

   NIH's Next Generation Researchers Initiative (https://grants.nih.gov/ngri.htm) has highlighted and increased support for early-stage investigators (ESIs), and ESI capacity in targeted areas, such as bBSSR, should be further pursued. The National Institute of General Medical Sciences' Maximizing Investigators' Research Award (MIRA) program (www.nigms.nih.gov/research/mechanisms/mira/pages/default.aspx) is an example of an effective program to support ESIs that could be expanded to target more

bBSSR laboratories supported by more ICs. NIDA's Behavioral Science Track Award for Rapid Transition (B/START) program (PAR-19-310; https://grants.nih.gov/grants/guide/pa-files/PAR-19-310.html) is a small but useful mechanism to provide new bBSSR investigators with the seed funding to conduct preliminary studies that make them more competitive for larger grant mechanisms. Adoption of a similar B/START program by other ICs would strengthen support for newly independent investigators.

bBSSR workforce diversity also can be strengthened internationally. Behavioral and social sciences research in developing countries is predominately applied research. bBSSR in developing countries should be encouraged, particularly research on social and behavioral mechanisms that are highly influenced by culture and context.

2. *Strengthen workforce training and capacity building.* In addition to diversity of backgrounds, the working group also addressed the diversity of research skills needed to advance bBSSR and identified several bBSSR capacity-building needs. Data science capabilities are a clear priority, and the Office of Behavioral and Social Sciences Research (OBSSR) Training in Advanced Data and Analysis for Behavioral and Social Sciences Research (TADA-BSSR) T32 program (https://obssr.od.nih.gov/obssr-t32-training-in-advanced-data-analytics-for-behavioral-and-social-sciences-research-grants-awarded), which integrated data science and behavioral and social science training, is an important step toward building data science capacity in bBSSR. The NIH has made data science, including artificial intelligence, a capacity-building priority.[6] Basic behavioral and social science researchers need to be included and integrated in these efforts, not only to apply artificial intelligence to social and behavioral research questions but also to minimize and address biases in training data sets that can be perpetuated as these algorithms are broadly applied.

   Although big data are increasingly important, data collection and analysis for rare diseases, small demographic groups, and other small but important populations require a unique set of research skills. Training in small-population research approaches should be encouraged by the NIH. Training in more sophisticated approaches to causal inference also is needed, both in true experimental and quasi-experimental approaches. These training needs should be considered across the career trajectory, including predoctoral T32s, pre- and post-doctoral fellowships (Fs), and various K awards.

3. *Foster team science and transdisciplinary integration*. Neglecting to incorporate bBSSR questions earlier and more substantially into biomedical research is a missed opportunity. As a recent example, the psychosocial impacts of COVID-19 illness and hospitalization could have been more extensively studied in the early therapeutic trials for relatively little additional cost or effort. Recently, another working group of the Council of Councils was chartered, based on congressional report language, to address behavioral and social sciences research integration, but this working group identified three key areas in need of greater bBSSR integration.

   3.1. *Strengthen the integration of bBSSR and neuroscience*. Although much of bBSSR is neuroscience-oriented, most NIH-funded neuroscience research is

not linked to behavioral or social phenomena, despite the primary function of the brain to regulate behavior. The second phase of the Brain Research through Advancing Innovative Neurotechnologies (BRAIN) Initiative (https://braininitiative.nih.gov/strategic-planning/acd-working-groups/brain-initiative%C2%AE-20-cells-circuits-toward-cures) holds promise to apply the tools developed in phase 1 to basic social and behavioral processes. This transition from tools to bBSSR needs to be prioritized and strengthened, not only in the BRAIN initiative but also other trans-NIH neuroscience initiatives and in IC-specific efforts.

3.2. *Increase the role of bBSSR in genetics research*. In addition to the epigenetic research area highlighted earlier, bBSSR associated with genetics is a relatively small component of the overall bBSSR portfolio despite considerable promise and opportunities that the integration of genetics and bBSSR provide. Genomic research would benefit from greater recognition that health disparities are fundamentally products of social disadvantage and that social environmental components affect disease processes and, therefore, are important for understanding genome function and trait diversity. Gene by environment research could characterize more precisely the complex and dynamic nature of environmental influences if conducted with sufficient power in large samples. Integrating these behavioral and environmental influences more substantially in large existing genomic studies could address some of these issues.

3.3. *Improve animal-human research integration.* The translation of animal research to human research needs to be strengthened. Support for animal and human subject research teams working in parallel on a common problem as well as support for cross-training of basic animal or human researchers would improve the translation between animal and human research.

3.4. *Support skills in interdisciplinary research and team science.* As bBSSR becomes increasingly integrated with other research areas, the ability to collaborate in a transdisciplinary team becomes imperative. The National Cancer Institute has been a leader in team science training efforts (www.cancer.gov/about-nci/organization/crs/research-initiatives/team-science-field-guide), and these efforts need to be expanded.

4. *Strengthen research infrastructure and processes.* The working group considered the scientific approaches and infrastructure needs of bBSSR, both in the promising and emerging areas of bBSSR outlined previously and the overall bBSSR portfolio that the NIH currently supports. To strengthen the scientific approaches, infrastructure needs, and management of bBSSR at the NIH, the working group offers the following recommendations.

4.1. *Encourage more multilevel research*. The NIH has encouraged multilevel research that incorporates social processes above the level of the individual; however, much of this research is predominately intra-individual in nature with a small social-contextual component. The NIH should consider encouraging research in areas that necessitate multilevel analysis. For instance,

environmental exposure and behavior is the smallest cluster in the bBSSR portfolio, but one for which multilevel research is critically important—especially given the serious health threats posed by climate change—and more research in this area would encourage more multilevel research as well.

4.2. *Strengthen basic-applied translational integration*. The translation from bBSSR findings to applied research is inadequate,[7] and basic research questions generated from applied research needs are insufficiently addressed. The working group identified a number of approaches that could improve translation. Although theoretical or "pure" bBSSR is important, more problem-focused or "use-inspired" research that bridges the gap from basic to applied to answer practical health questions should be encouraged. This requires drawing participants from relevant populations, using real-world grounded measures and procedures, and assessing real-world behavioral outcomes. Some of the smaller clusters of bBSSR are more disease focused and, therefore, more proximate to translation (e.g., pain, substance abuse). Increased support by the ICs for bBSSR directly relevant to their missions should improve translation. The Science of Behavior Change (SOBC; https://commonfund.nih.gov/behaviorchange) Common Fund effort was an important demonstration of testing basic mechanisms for applied translation. With SOBC transitioning from Common Fund support, a focused effort to strengthen and maintain bBSSR translation should be considered. A potential limitation in improving the translational process of bBSSR is that the current NIH portfolio analysis tools to identify translational potential do not fit well with bBSSR. OBSSR and OPA should work together to develop a translational analysis tool for the behavioral and social sciences that would allow the NIH to improve its ability to identify and monitor the translation of its bBSSR investments.

4.3. *Accelerate advances in epidemiology and population health approaches*. Several ICs (e.g., NIA, NICHD, NIDA, the National Heart, Lung, and Blood Institute) have strong epidemiology and population health efforts, and the NIH has launched a number of trans-NIH initiatives that will advance epidemiological and population health research (e.g., the Adolescent Brain Cognitive Development study, *All of Us*, the Environmental influences on Child Health Outcomes program). One approach in this research area that should be accelerated is the increasing use of technology and administrative databases for extracting population heath–relevant phenomena. The NIH also should encourage more longitudinal and mechanistically-driven research. Finally, the NIH and other government research entities support a wide and diverse set of epidemiological and population survey research, and these efforts could be better integrated. Addressing the integration of population-level research is a substantial and potentially expensive task, but it is a critical need to advance epidemiology and population health research.

4.4. *Develop and expand bBSSR data repositories.* bBSSR suffers from inadequate resources for data sharing and integration, not only in population-level research but even more so in laboratory-based research. An increased focus on bBSSR

data repositories and data sharing support (e.g., common or well-documented procedures, common or co-calibrated measures, common data elements) is needed and is consistent with NIH efforts to enhance rigor and reproducibility in scientific research.[8]

4.5. *Strengthen trans-NIH bBSSR and coordination with NIH ICs and with the NSF.* The NIH ICs have supported and should continue to support bBSSR relevant to their missions, and some of the ICs with smaller bBSSR portfolios should work with OBSSR to identify relevant bBSSR priorities. Some recommendations of this report can be addressed adequately at the IC level. Nevertheless, much of the NIH bBSSR portfolio is relevant across multiple ICs and thus requires trans-NIH effort and coordination. OppNet provided a productive, but temporary, home for trans-NIH bBSSR efforts and, in its current voluntary participation form, functions similarly to OBSSR for identifying and supporting trans-NIH behavioral and social sciences research needs. There is value, however, in having a strong trans-NIH bBSSR coordination and NIH leadership level direction. This could be achieved with a high-level bBSSR coordination group consisting of IC Directors, or their delegates, representing the ICs with substantial bBSSR funding to determine trans-NIH bBSSR needs and directions, as well as possibly a pooled funding source (similar to the NIH Blueprint model). In addition to evaluating bBSSR funding directions and considering potential collaborative efforts of the NIH, this group also could meet periodically with the leadership of the NSF Social, Behavioral, and Economics Directorate to discuss complementary research funding efforts and possible cross-agency collaborations in areas of shared interest.

Executive Summary Conclusion

bBSSR at the NIH is in a very different position than it was in 2004 when the first report on bBSSR was released. There have been advances in scientific approaches, new discoveries, and in recent years, increased funding for bBSSR by the NIH. Although bBSSR support has strengthened in recent years, critical areas of need remain, as well as emerging and promising new areas that the NIH should consider accelerating. Continued improvements in the diversity of the bBSSR workforce are needed, and the NIH can ensure that its various workforce diversity efforts not only include bBSSR, but also draw upon lessons learned from the BSSR workforce. bBSSR has extensive scientific approach and infrastructure needs that the NIH should consider addressing to advance the field. Overall, bBSSR is an important and foundational part of the NIH research enterprise and, with targeted effort in the areas outlined in this report, can play an increased role in addressing the NIH mission and the urgent public health issues facing the nation and the world.

Full Report of the NIH Council of Councils Working Group on Trans-NIH Research Opportunities in the Basic Behavioral and Social Sciences

Impetus and Charge of the Working Group

In 2004, a Working Group of the National Institutes of Health (NIH) Advisory Committee to the Director (ACD) reported on the Research Opportunities in the Basic Behavioral and Social Sciences.[2] The report described the basic behavioral and social sciences research (bBSSR) funded by the NIH at that time and recommended a "home" for bBSSR that is relevant to the NIH mission but does not fit within the mission of any one NIH Institute or Center (IC). This report was the impetus for creating OppNet (https://oppnet.nih.gov), a trans-NIH initiative funded from 2009 to 2014 primarily through dedicated support from the NIH ICs and since 2014 via voluntary support from participating ICs. (See Appendix A for a summary of the 2004 report and of OppNet activities and evaluation.)

In the 17 years since this prior report was issued, much has changed, both in the bBSSR field and in NIH support for this research area. Scientific advances in neuroscience, behavioral assessment, data science, and statistical and computational modeling are transforming the basic behavioral and social sciences.[9] Future directions for NIH-supported bBSSR need to be considered in the context of these transformative advances. In addition, a number of trans-NIH initiatives launched in recent years have the potential to integrate and advance bBSSR (e.g., Adolescent Brain and Cognitive Development [ABCD], *All of Us*, the Brain Research through Advancing Innovative Neurotechnologies [BRAIN] Initiative, and Environmental influences on Child Health Outcomes [ECHO]).

Substantial changes in NIH bBSSR funding have occurred since the last report. The 2004 report highlighted concerns about limited NIH support for bBSSR, and OppNet was created to help address those concerns. During the dedicated OppNet funding period—in which this program provided $64 million in bBSSR support—overall NIH support for bBSSR remained relatively flat; however, during the subsequent period of limited voluntary funding for OppNet, overall NIH funding for bBSSR doubled from $297 million in fiscal year (FY) 2014 to $652 million in FY 2019. During this same period, NIH extramural funding support overall increased by approximately 30 percent, indicating that the growth of bBSSR during this time exceeded the growth of NIH funding support overall. Given these changes in the field and in the support of bBSSR since the 2004 report, an updated evaluation of the NIH bBSSR research portfolio appeared warranted to assist the NIH in targeting its future bBSSR investment toward promising areas of research that have a plausible translational pathway to applied health research.

Charge

In light of these changes since the 2004 report, a working group of the NIH Council of Councils was established on May 15, 2020, and charged with addressing the following questions:

1. What are the promising and emerging areas of bBSSR that are priorities for NIH support (i.e., have a plausible translational pathway to health-relevant applied research, not supported under the mission of another funding agency)?
2. Which of these emerging areas of research are not adequately supported by the current NIH bBSSR portfolio?
3. Can these inadequately addressed emerging areas of research be addressed by individual IC efforts or do some require a trans-NIH effort to address?

Working Group processes to address this charge are described in Appendix B.

Scope and Definition of Basic Behavioral and Social Sciences Research

When the U.S. Congress created the Office of Behavioral and Social Sciences Research (OBSSR) at the NIH, it mandated that the Office develop a standard definition of the field to assess and monitor funding in this area. The definition developed in 1996 was revised in 2019 based on input from the behavioral and social sciences research community. The 2019 definition states, "*Behavioral and social sciences research at the National Institutes of Health involves the systematic study of behavioral and social phenomena relevant to health*." (https://obssr.od.nih.gov/about/bssr-definition)

- *Behavioral phenomena* refer to the observable actions of individuals or groups and to mental phenomena, such as knowledge, attitudes, beliefs, motivations, perceptions, cognitions, and emotions.
- *Social phenomena* refer to the interactions between and among individuals and to the characteristics, structures, and functions of social groups and institutions, such as families, communities, schools, and workplaces, as well as the physical, economic, cultural, and policy environments in which social and behavioral phenomena occur.

Health refers to state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity (as per the World Health Organization[10]).

Consistent with Federal code, the NIH defines basic research as "the systematic study directed toward greater knowledge or understanding of the fundamental aspects of phenomena and of observable facts without specific applications towards processes or products in mind" (32 CFR 272.3; https://www.govinfo.gov/app/details/CFR-2012-title32-vol2/CFR-2012-title32-vol2-sec272-3). This general definition of basic research is applicable to basic research involving behavioral and social phenomena as well.

Therefore, the NIH defines bBSSR as "research that furthers our understanding of fundamental mechanisms and patterns of behavioral and social functioning, relevant to the Nation's health and well-being, and as they interact with each other, with biology and the environment" (https://oppnet.nih.gov/about/b-bssr-definition).

The NIH has a long-term commitment to basic or foundational research,[11] and the current NIH-Wide Strategic Plan calls out basic behavioral and social sciences as within its mission and the basic research that the NIH funds.

> "Fundamental science also includes bBSSR that generates knowledge of how living systems interact with and are influenced by experiences at the individual, family, social, organizational, and environmental levels. NIH-supported research on the neurobiological and learning mechanisms of goal-directed versus habitual behaviors provide important insights on how unhealthy habitual behaviors can be brought under greater control and how behavior change can be maintained. The study of stress responses and stress resilience offers potential approaches to help individuals better adapt to negative life events. Understanding decision-making processes, especially under various emotional and cognitive states, also sheds new light on how medical decisions, both by provider and patient, are made and can be improved. NIH-supported bBSSR serves as the foundation for the development of innovative approaches to improve health via changes in behavior and the environment." (*NIH-Wide Strategic Plan*,[1] pp. 15–16)

bBSSR is crucial to addressing the pressing health and public health needs of the nation and the world. Many of the urgent current public health issues, such as COVID-19 transmission, structural racism, health disparities, firearm violence, and opioid addiction, are predominantly social and behavioral in nature. Effectively addressing these and other health issues requires a robust bBSSR agenda that can support new and innovative approaches to changing behaviors and social systems.

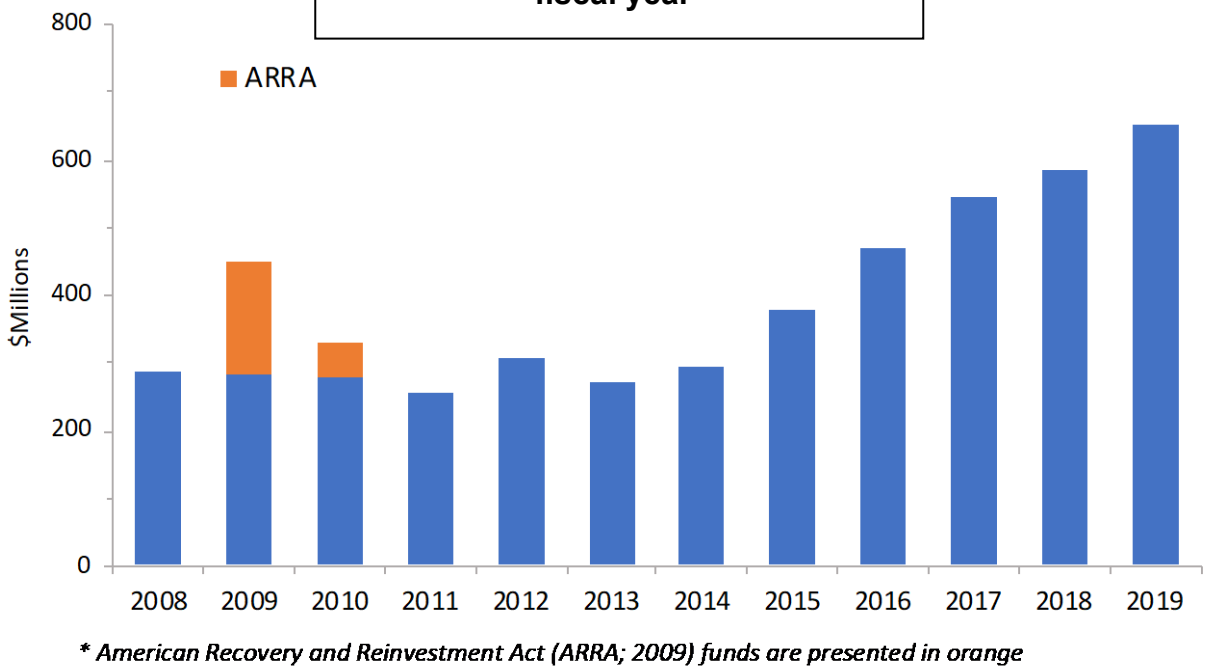
NIH bBSSR Funding

bBSSR funding by the NIH in this report is based on Research, Condition, and Disease Categorization (RCDC) System codes for bBSSR from FY 2008 to FY 2019, filtered for NIH Type 1 and Type 2 (competitive) Research Project Grants (RPGs). Costs have been adjusted to 2019 dollars using the Biomedical Research and Development Price Index. Because the RCDC Categorical Spending Report (https://report.nih.gov/funding/categorical-spending#/) includes noncompetitive (e.g., Type 5) as well as competitive projects, the bBSSR funding described in this report is a subset of the RCDC categorical spending for bBSSR, focused on new or competitively renewed bBSSR funding.

After a period of relatively flat bBSSR support from FY 2008 through FY 2014 (excluding the American Recovery and Reinvestment Act [ARRA] funding), NIH bBSSR support doubled from $296 million in FY 2014 to $652 million in FY 2019. Note that the full RCDC categorical spending also shows this doubling, from $1.23 billion to $2.56 billion. This period of doubling coincides with an approximately 30 percent

increase in NIH extramural funding support overall, indicating that this growth in bBSSR support exceeded the overall funding increases of the NIH during this time period. Figure 2 shows the increase in bBSSR funding from FY 2008 through FY 2019.

Figure 2. NIH bBSSR investment by fiscal year*



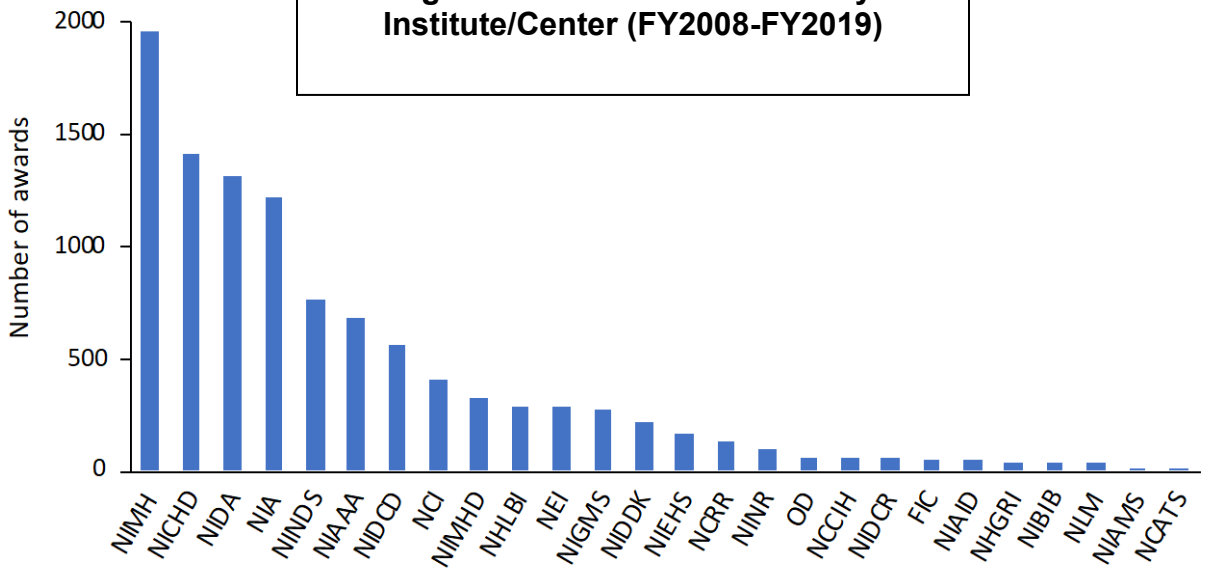
** American Recovery and Reinvestment Act (ARRA; 2009) funds are presented in orange*

Figure 1. NIH bBSSR investment by fiscal year.

These data are based on RCDC codes for bBSSR, which count as bBSSR any grant that has a sufficient bBSSR aim or component to be included. As a result, grants considered bBSSR can range from predominately biomedical research grants with a small bBSSR component to grants in which most or all of the variables of interest represent behavioral and/or social phenomena. As a result, grant funding based on RCDC overestimates the investment in research that is predominately bBSSR in nature, but this metric does provide a reliable indication of trends over time.

bBSSR awards by IC from FY 2008 through FY 2019 are displayed in Figure 3. NIH ICs that have funded more than 1000 bBSSR grants during this period are the National Institute of Mental Health (NIMH), the *Eunice Kennedy Shriver* National Institute of Child Health and Human Development (NICHD), the National Institute on Drug Abuse (NIDA), and the National Institute on Aging (NIA). The ICs that have funded between 500 and 1000 bBSSR grants during this period are the National Institute of Neurological Disorders and Stroke (NINDS), the National Institute on Alcohol Abuse and Alcoholism (NIAAA), and the National Institute on Deafness and Other Communication Disorders (NIDCD).

Figure 3. NIH bBSSR awards by Institute/Center (FY2008-FY2019)



To provide more in-depth analysis of the bBSSR portfolio, the Office of Portfolio Analysis (OPA) analyzed all RCDC bBSSR RPGs from FY 2008 through FY 2019. OPA used an artificial intelligence/machine learning (word2vec$_{OPA}$) approach to identify mutually exclusive clusters of bBSSR grants based on the content of titles, abstracts, and specific aims. The optimal number of clusters (30) was confirmed by silhouette analysis. Total costs were adjusted to FY 2019 dollars. Type 1 and 2 (competitive) bBSSR awards during this time period totaled 10,524. R01s were the predominant award mechanism, accounting for nearly 50 percent of total awards, followed by R21s and R03s.

Word2vec$_{OPA}$ machine learning revealed 30 clusters of bBSSR shown in Table 1. Labels for these clusters were determined by subject-matter expert review of the award titles within each cluster, but it should be noted that some of these labels suggest overlapping or closely related clusters. The largest number of awards in bBSSR from FY 2008 through FY 2019 were in the areas of functional neuroanatomy and neurophysiology, neurobiology of behavior, cognition and learning, child development, addictive processes, community and population influences, and health disparities, all with more than 500 awards per clusters. The smallest number of bBSSR awards were in the areas of environmental exposures and behaviors, epigenetics, pain perception and modulation, sexual risk behaviors and sexual and gender minority (SGM) health, sleep and circadian function, nicotine and tobacco dependence, and dementia and neurodegeneration, all with fewer than 200 awards within each cluster.

Table 1. NIH bBSSR award counts by topic area (word2vec$_{opa}$) (FY2008-FY2019)

Topic area	Award count	Topic area	Award count
Functional neuroanatomy and neurophysiology	733	Cellular and molecular neuroregulation of behavior	291
Neurobiology of behavior	656	Neurocircuitry and receptors	277
Cognition and learning	639	Appetite and weight	265
Child development	577	Prenatal and infant health	260
Addictive processes	565	Neuroimmunology and inflammatory processes	259
Community and population influences	564	Neuroendocrine research	252
Health disparities	513	Hearing and speech perception	223
IT research tools	487	Genetic influences on behavior	220
Neurophysiology and behavior	443	Dementia and neurodegeneration	199
Training programs	393	Nicotine and tobacco dependence	193
Language	392	Sleep and circadian functions	186
Health services research	352	Sexual risk behaviors and SGM health	180
Neuropathology and behavior	332	Pain perception and modulation	169
Translation to assessment and intervention	328	Epigenetics	161
Alcohol use	319	Environmental exposures and behavior	96

Figure 4. NIH bBSSR investment by topic area (FY2008-FY2019)

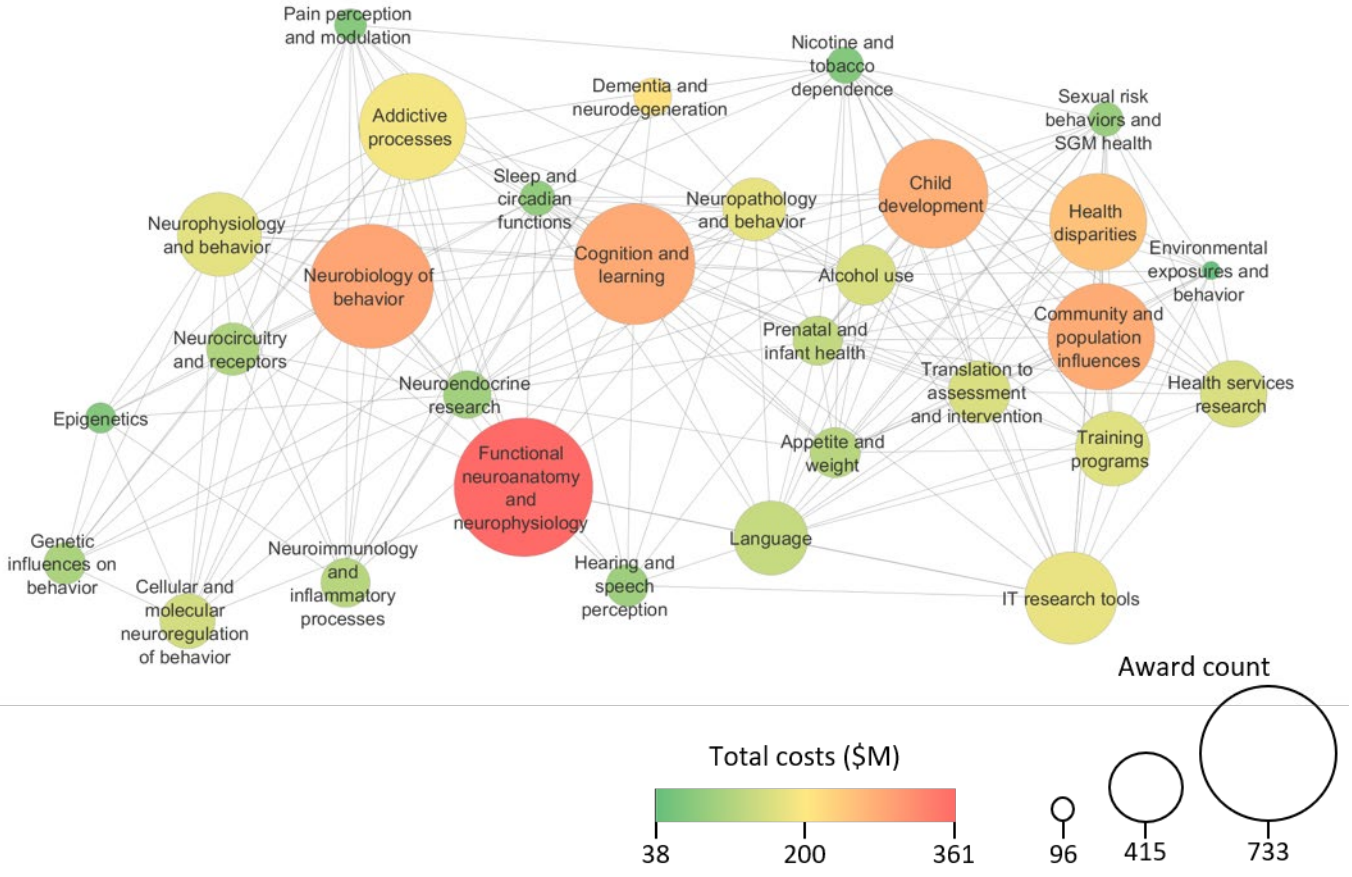


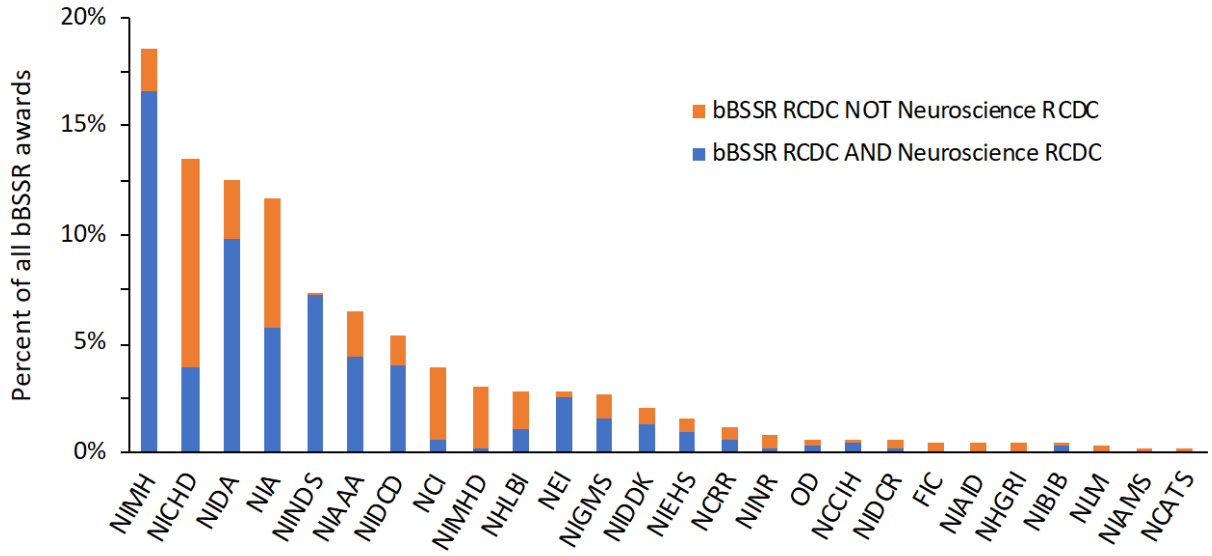
Figure 4 (also labeled Figure 1 in the Executive Summary) shows these clusters in relation to one another with the size of the circle representing the number of grants awarded within each cluster and the color of each circle representing the total dollar amount of grant awards by each cluster. Although all areas of bBSSR are interrelated, this graphic suggests two subsets of clusters, one predominately bench- or laboratory-based research associated with the fields of neuroscience and genetics (left side) and one predominantly field research, including community and population research as well as research directly relevant to specific behavioral problems or disease conditions (right side).

Although bBSSR represents a broad range of research from functional neurophysiology to community and population influences, this graphic illustrates bBSSR's highly interrelated nature. The research represented by these clusters also illustrates the integration of bBSSR with other basic science areas including but not limited to endocrinology, genetics, immunology, inflammatory processes, and neuroscience supported by the NIH. This integration is consistent with the perspective of cognitive and psychological sciences as "hub sciences" that facilitate scientific integration.[12,13]

To further explore the high level of integration of bBSSR and neuroscience, the intersection of RCDC codes for bBSSR and for neuroscience was calculated: 62.1 percent of bBSSR awards were also coded as neuroscience but only 15.1 percent of neuroscience awards were also coded as bBSSR. This suggests that of the considerable NIH research support for neuroscience, only a small proportion extends neuroscience into understanding behavioral or social phenomena; however, nearly two-thirds of the bBSSR funded by the NIH has a neuroscience component. The increases in bBSSR funding since 2014 may be explained in part by increased support for neuroscience initiatives in recent years.

A breakdown by IC of bBSSR grants that are also coded as neuroscience or not is displayed in Figure 5. The neuroscience-oriented ICs (NIMH, NIDA, NINDS, NIAAA, NIDCD, and the National Eye Institute [NEI]) predominately fund bBSSR that is also categorized as neuroscience. bBSSR that is not also categorized as neuroscience is funded mostly by NICHD, NIA, the National Cancer Institute (NCI), the National Institute on Minority Health and Health Disparities (NIMHD), and the National Heart, Lung, and Blood Institute (NHLBI).

Figure 5. NIH bBSSR awards by Institute/Center – RCDC categories (FY2008-FY2019)



Of the 62,687 bBSSR applications from FY 2008 through FY 2019, 10,524 were awarded. Table 2 shows the award rates by bBSSR cluster. Training programs, translational research, and IT research tools were the areas with the highest award rates. Among the more content-specific clusters, cellular and molecular neuroregulation of behavior, community and population influences, health services research, and neurobiology of behavior applications had the highest award rates. The lowest award rates were in the topics of sexual risk behaviors and SGM health, neuroimmunology and inflammatory processes, and neurocircuitry and receptors. Although these award rate differences may reflect the scientific rigor and impact of these research areas, it likely also reflects differences in IC budgets and funding priorities.

Table 2. NIH bBSSR award rate by topic area (word2vec$_{OPA}$) (FY2008-FY2019)

Topic area	Award rate		
Training programs	26.2%	Sleep and circadian functions	15.7%
Translation to assessment and intervention	25.1%	Prenatal and infant health	15.5%
IT research tools	24.3%	Environmental exposures and behavior	14.9%
Cellular and molecular neuroregulation of behavior	22.3%	Neurophysiology and behavior	14.9%
Community and population influences	20.4%	Alcohol use	14.6%
Health services research	20.4%	Dementia and neurodegeneration	14.2%
Neurobiology of behavior	20.2%	Epigenetics	14.0%
Functional neuroanatomy and neurophysiology	20.1%	Neuroendocrine research	13.9%
Hearing and speech perception	18.7%	Child development	13.9%
Addictive processes	18.2%	Genetic influences on behavior	13.8%
Nicotine and tobacco dependence	17.2%	Neuropathology and behavior	13.7%
Cognition and learning	16.3%	Pain perception and modulation	13.3%
Health disparities	16.2%	Neurocircuitry and receptors	12.3%
Appetite and weight	15.9%	Neuroimmunology and inflammatory processes	11.5%
Language	15.8%	Sexual risk behaviors and SGM health	11.4%

To evaluate productivity and scientific influence from these bBSSR clusters, OPA calculated the following for all of the grants awarded within each cluster: (1) the mean number of publications per award, (2) the median Relative Citation Ratio (RCR),[14] and (3) the mean Approximate Potential to Translate (APT).[15] These indices by cluster are displayed in Table 3, ordered by median RCR. Excluding IT research tools as an outlier, the clusters with the higher number of publications per award were environmental exposures and behavior, health disparities, health services research, training programs, sexual risk behaviors and SGM health, and dementia and neurodegeneration. Two clusters—nicotine and tobacco dependence and cellular and molecular neuroregulation of behavior—had a mean of fewer than 10 publications per award. The clusters with the higher median RCRs, indicating greater scientific influence from a normalized citation perspective, were dementia and neurodegeneration, neurobiology of behavior, epigenetics, neuroimmunology and inflammatory processes, and neuropathology and behavior. Language and training programs were the only clusters with median RCRs less than 1, indicating a lower than expected citation rate. The clusters with higher potential for translation, as indicated by their APT scores, were dementia and neurodegeneration, neuropathology and behavior, nicotine and tobacco dependence, alcohol use, and cognition and learning. The applicability and relevance of the APT metric for assessing translational potential of bBSSR, however, requires further study.

Table 3. Research productivity and Influence by cluster

Cluster Name	Pubs per award	Median RCR	Avg APT
Dementia and neurodegeneration	25.65	1.59	0.55
Neurobiology of behavior	10.27	1.53	0.30
Epigenetics	10.55	1.52	0.32
Neuroimmunology and inflammatory processes	13.05	1.51	0.36
Neuropathology and behavior	20.85	1.44	0.55
Cognition and learning	15.61	1.40	0.52
Appetite and weight	24.64	1.37	0.49
Sleep and circadian functions	13.71	1.37	0.48
Alcohol use	18.20	1.35	0.53
Neurophysiology and behavior	12.01	1.35	0.31
Addictive processes	15.12	1.32	0.38
Pain perception and modulation	18.30	1.31	0.43
Environmental exposures and behavior	39.27	1.30	0.40
Neurocircuitry and receptors	10.81	1.24	0.23
Functional neuroanatomy and neurophysiology	15.53	1.22	0.38
Cellular and molecular neuroregulation of behavior	9.44	1.16	0.12
Nicotine and tobacco dependence	9.20	1.16	0.53
Child development	12.44	1.15	0.48
Health disparities	36.91	1.14	0.48
Genetic influences on behavior	16.75	1.14	0.37
Hearing and speech perception	16.22	1.14	0.42
IT research tools	110.15	1.13	0.46
Translation to assessment and intervention	14.04	1.13	0.49
Neuroendocrine research	15.87	1.09	0.31
Prenatal and infant health	13.63	1.08	0.41
Health services research	31.68	1.07	0.45
Sexual risk behaviors and SGM health	27.39	1.02	0.46
Community and population influences	18.63	1.01	0.47
Language	13.52	0.98	0.39
Training programs	28.72	0.97	0.47

RCR: Relative Citation Ratio (DOI: pbio.1002541)

APT: Approximate Potential to Translate (DOI: pbio.3000416)

Note: Table is sorted by Median RCR high-low

Overall, these analyses of bBSSR funding by the NIH indicate that despite the prior concerns about inadequate attention to bBSSR funding that in part prompted the 2004 report, and after relatively flat funding from 2008 through 2014, NIH funding for bBSSR has increased during the last 5 years, outpacing the growth of NIH funding overall during this time period. Seven ICs (NIMH, NICHD, NIDA, NIA, NINDS, NIAAA, and NIDCD) fund much of the bBSSR that the NIH supports. The research areas of functional neuroanatomy and neurophysiology, neurobiology of behavior, cognition and learning, child development, addictive processes, community and population influences,

and health disparities represent a larger proportion of bBSSR awards than the research areas of environmental exposures and behaviors, epigenetics, pain perception and modulation, sexual risk behaviors and SGM health, sleep and circadian function, nicotine and tobacco dependence, and dementia and neurodegeneration. Some of these smaller clusters, however, have disproportionally larger influence (e.g., high median RCRs for dementia and neurogeneration, epigenetics) and greater potential for translation (e.g., high mean APTs for dementia and neurodegeneration, nicotine and tobacco use).

What are the promising and emerging areas of bBSSR that are not adequately supported by the NIH? (Charge questions 1 and 2)

Based on review of the NIH bBSSR portfolio, input from program officers, and discussions of the working group (see Appendix B for Working Group Process), a number of promising and emerging areas of bBSSR were identified. The areas described below, however, should be considered in the context of NIH's maintaining bBSSR support in core areas. Core bBSSR supported by the NIH includes research on cognitive processes, such as attention, learning, and memory; developmental processes; behavioral, cognitive, and social neuroscience; social systems; and epidemiology and population health. It is critical that NIH continue to maintain and strengthen these core areas of bBSSR while considering how to better prioritize the emerging and promising research directions that follow.

1. *Behavioral, cognitive, and social neuroscience.* Among the promising areas of behavioral, cognitive, and social neuroscience areas in need of further study and research supported by the NIH include the following:

    1.1. *Increased focus on how specific experiences "get into the brain."* The brain is the most malleable of organs in response to the environment, and its functions are largely designed to react to, predict, and regulate the environment. Although researchers now have a much better understanding of how memories are stored in the brain, much more remains to be learned about how everyday experiences are selected, processed, stored, and used by the brain. Further research on event representations[16] in perception, learning, and memory—including more work on developmental changes and on computational neuroscience models for these event representations—is needed.

    1.2. *Greater focus on the role of understudied regions of the brain in behavior.* A map of neuroscience research interests by brain regions would show areas of the brain that have attracted considerable research interest (e.g., prefrontal cortices) and areas of the brain that have been relatively ignored (e.g., cerebellum). This may reflect, in part, limitations in brain–behavior relationships that have been measurable using laboratory-based behaviors or the limitations of current technologies for studying these less-studied brain regions. The role of these less-studied brain regions on behavior is an area that should be further explored.

1.3. *Increased integration of current, largely separate research tracts involving how behavior and social environment are embodied in the brain versus in the periphery.* Integrating these separate tracts could reveal novel and interesting findings about the mechanisms these representations hold in common versus those that are distinct. Integration also holds promise for understanding how the brain and the rest of the body interact to control behavior and contribute to disease processes. In some cases, research integrating these brain and body interactions may fall through the cracks between the more brain-oriented ICs (e.g., NINDS, NIMH, NIDA, NIAAA) and the ICs focused more on non-brain disease processes (e.g., NCI, the National Institute of Allergy and Infectious Diseases [NIAID], NHLBI, the National Institute of Diabetes and Digestive and Kidney Diseases [NIDDK]). Areas of research that would naturally integrate brain and body processes, such as pain perception and modulation, are underrepresented in the NIH bBSSR portfolio, and other areas, such as neuroimmunology and inflammatory processes, have low award rates but are highly influential areas of science. Whether through the Helping to End Addiction Long-term℠ Initiative (NIH HEAL Initiative℠) or other trans-NIH efforts, increased research on how the brain and other organ systems interact to experience and regulate behavior appears warranted.

2. *Epigenetics.* One area of increasing interest that integrates genetics and social/environmental influences is epigenetics. Epigenetic modification is only one of many ways in which the environment influences the role of genetics in health and disease processes, but it is an important area in need of greater focus. Epigenetics is among the smallest clusters of NIH support in bBSSR, but it also appears to be among the most influential from a publication and citation perspective. OppNet had a recent initiative addressing epigenetics, but by the nature of OppNet funding, this initiative was relatively small. A more concerted trans-NIH epigenetics effort appears needed. Given the fast pace of discovery in "core" epigenetics/epigenomics research in the genome sciences, this area would particularly benefit from interdisciplinary collaboration from experts both in epigenetics and in behavioral and social processes.

> Children raised in poorer neighborhoods exhibited differential DNA methylation in genes related to chronic inflammation, tobacco smoke, air pollution and lung cancer. Associations between neighborhood disadvantage and methylation were small but robust to family-level socioeconomic factors and to individual-level tobacco smoking. Because children raised in disadvantaged neighborhoods enter young adulthood epigenetically distinct from their more privileged peers, this study suggests the epigenetic effects of childhood neighborhoods on adult health but also research for future mechanistic research on processes that may ameliorate these disparities and increase health equity.[17]

3. *Basic functions of sleep and sex research.* Research on two basic functions, sleep and sex, is a very small subset of the bBSSR portfolio. These topics are sometimes appended to other research areas (e.g., sleep apnea, HIV risk behaviors) but they should be sufficiently studied in their own right. Research on sleep and on sexual behavior generates foundational knowledge to understand a range of health and illness processes. Wellness also is substantially influenced by sleep and sexual

behavior. Neither of these basic research areas falls clearly within one or more IC missions (even though the National Center for Sleep Disorders is housed within NHLBI), and this limited organizational support for research on these basic functions may contribute to the small amount of current support for these areas. For each of these areas, the NIH should conduct a more in-depth study of the research currently supported, identify key research gaps, and devise programs to address these gaps and increase support for these basic science areas.

4. *Infectious disease basic behavioral and social processes.* The COVID-19 pandemic clearly demonstrated the insufficient research base for the social and behavioral processes that influence infectious disease transmission and mitigation. Computational modeling of infectious disease transmission, including some behavioral and social parameters, is supported by the NIH, but key research to estimate such parameters as the adherence to various mitigation instructions and the mechanisms that influence such adherence is lacking. Research on persuasion and decision making for following mitigation measures, getting tested, and getting vaccinated is clearly needed to provide the foundation for improved public health interventions for infectious disease control and mitigation. Even in the absence of the COVID-19 pandemic, HIV, influenza, and various infectious disease processes need a strong bBSSR agenda to inform the development of effective public health education and persuasion research studies. NIAID is the natural home for such research, but whether housed at NIAID or some combination of NIH Institutes, the need for such research is clearly illustrated by the COVID-19 pandemic and the disparities observed from the pandemic.

> Long-standing systemic health and social inequities have put many people from racial and ethnic minority groups at increased risk of getting sick and dying from COVID-19. Previous research found physical distancing to be an effective prevention measure during the H1N1 pandemic in 2009, particularly among higher socioeconomic households. This research team assembled a longitudinal data set of anonymized and aggregated smartphone daily mobility measures, state-level emergency declarations for January–April 2020, and American Community Survey data to construct median income quantiles for county and census tracts for locales. Using an event study design focusing on behavior after state emergency orders, the researchers found that social distancing following emergency state declarations increased overall, but dramatically increased among devices whose homes were located in higher-income locations. The study showed that people in lower-income U.S. communities are more vulnerable to the economic and health impacts of COVID-19, in part because they are less likely to be able to physically distance and reduce their mobility than people in higher income communities.[18]

5. *Influences of social interactions on health.* The bBSSR supported by the NIH focuses predominately on the individual and to a lesser extent on broad social units of analysis such as communities and large population groups. In contrast, the NIH supports relatively little research on the influence of dyads, families, and other small social group interactions and networks on health. This gap is analogous to an earlier era of neuroscience in which research focused predominately on either neurons or brain regions, and less so on the neurocircuitry that links neurons and brain regions. The BRAIN Initiative and other NIH neuroscience efforts have bridged this

neurocircuitry gap, and a similar effort to bridge the social interactions research gap between intra-individual and population-level influences on health is needed.

Recently, OppNet released a funding opportunity announcement (FOA) to encourage research on the influence of social connectedness and isolation on health (PAR-21-144; https://grants.nih.gov/grants/guide/pa-files/PAR-21-144.html). This is a small but important start toward a more extensive and comprehensive research effort to understand social interactions and the mechanisms by which social connectedness impacts health outcomes. Social network analysis approaches and technological advances that automate the characterization of social interactions now provide new methods to study inter-individual processes and how they influence health. This is an area of bBSSR in which a substantial trans-NIH research investment appears warranted.

> Adolescence is a vulnerable period for the development of loneliness, particularly for individuals with autism spectrum disorder (ASD), and feelings of loneliness predict significant negative mental and physical health outcomes. This grant follows matched ASD and typically developing (TD) adolescents for 20 months, collecting ecologically valid, naturalistic, and social-interactive Functional magnetic resonance imaging—including smartphone-based ecological momentary assessments to obtain real-world assessments of social experiences and their effects on mood and loneliness. This project is poised to illuminate the mechanisms that confer risk and protection in the development of loneliness in adolescence, whether they differ in high-risk populations, with direct implications toward interventions to mitigate the experience of loneliness and associated negative outcomes in high-risk adolescents with ASD and TD. (R01MH125370-01)

6. *Basic processes maintaining versus initiating behavior change.* Much of the basic science relevant to behavior change has focused on the mechanisms that initiate behavior change, less so on the mechanisms that maintain behavior change. Maintenance of behavior change, however, is a critical challenge in intervention research that commonly exhibits a "checkmark" change process in which initial behavior change success is followed by partial or even full return to baseline once the intervention is completed. OppNet funded a small initiative focused on behavioral maintenance processes more than a decade ago (RFA-HL-11-035; https://grants.nih.gov/grants/guide/rfa-files/RFA-HL-11-035.html), but much more basic research is needed to understand the transition from behavioral initiation to maintenance and the mechanisms, including environmental and contextual mechanisms

> The dorsolateral striatum (DLS) is implicated in habit formation, yet its mechanisms remain unclear. An ESI-led team project imaged cortically evoked firing in large populations of pathway-defined striatal projection neurons (SPNs) and identified features that strongly correlate with habitual behavior on a subject-by-subject basis. Habitual behavior correlated with strengthened DLS output to both pathways and a tendency for action-promoting direct pathway SPNs to fire before indirect pathway SPNs. In contrast, habit suppression correlated solely with a weakened direct pathway output. These findings indicate that the striatum imposes broad, pathway-specific modulations of incoming activity to render learned motor behaviors habitual.[19]

that support continued maintenance of behavior change. Basic processes such as the transition from goal-directed to habitual learning, implicit learning, and other processes need to be more extensively studied to provide the basic science needed to apply to novel intervention strategies that maintain behavior change over time.

7. *Balance of positive and negative health processes.* The organization of NIH ICs predominately by disease processes leads to basic research that focuses primarily on the processes that contribute to disease and disability. The increasing support of bBSSR among the ICs in the past few years is encouraging and should continue, but this support focuses predominantly on illness processes, not health processes. Although this orientation is understandable, it has the tendency to give inadequate attention to the basic processes that support improved health and well-being. As the WHO stated more than a half century ago, "Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity."[10] There are gradations not only of disease and disability, but also of health and wellness. More NIH support for research on the basic processes that lead to greater health and wellness of individuals and populations will provide greater balance in the understanding of positive and negative health processes. In addition to improving our understanding of positive health, such research may provide useful insights into mechanisms that make some individuals more susceptible or resilient to illness than others. Some ICs, by virtue of their non-disease focus (e.g., the National Institute of Nursing Research [NINR], NICHD, NIA, the National Center for Complementary and Integrative Health [NCCIH]) are well positioned to strengthen basic behavioral sciences research on positive health processes, but all ICs have a role in achieving this balance, and a trans-NIH effort may be needed to encourage more research on the basic processes that promote resilience, wellness, and a meaningful life.
8. *Basic research that informs the science of science.* Human research struggles with declining rates of participation, both in recruitment and retention, that negatively affect the generalizability of findings. Many of the practical challenges in conducting research with humans are social and behavioral in nature. Ethical and social issues of research participation are most often considered as an application of behavioral and social sciences to the conduct of research, but many other applications exist, such as encouraging participation in research and building trust in science, especially with underrepresented minorities (URMs). Many areas of basic behavioral and social sciences—including research on altruism, trust, persuasion, reinforcement, behavioral economics, and counterfactual thinking—can provide a foundation for new applied approaches to promote successful study protocol participation and facilitate the translation of health-related research to the real world through improved science communication and greater trust in and understanding of the scientific process. Whether as a trans-NIH effort or the focused effort of a few ICs, a robust basic metascience portfolio in the mechanisms that contribute to research participation, research policy, and trust in science, particularly on the part of URMs, appears needed.

Can these inadequately addressed emerging areas of research be addressed by individual IC efforts, or do some require a trans-NIH effort to address?

To address this question, the working group took a comprehensive perspective that considered not only the promising areas identified above but also the entire NIH bBSSR portfolio. This view included considerations of workforce diversity and capacity building needs, transdisciplinary integration of bBSSR in the broader NIH biomedical research enterprise, and research process and infrastructure needs, including trans-NIH bBSSR coordination and support.

1. *Increase workforce diversity.* The NIH has created a number of programs to strengthen and diversify the health research workforce, including the Institutional Developmental Award (IDeA) program (https://www.nigms.nih.gov/Research/DRCB/IDeA/Pages/default.aspx) to broaden geographic diversity, the Next Generation Research Initiative (https://grants.nih.gov/ngri.htm) to increase support for early-stage investigators (ESIs), and various initiatives to increase the diversity of the scientific workforce, most recently as part of the UNITE initiative (https://www.nih.gov/ending-structural-racism/unite). These programs are relevant to bBSSR researchers as well, and the working group strongly endorses NIH efforts to create a more diverse and inclusive scientific workforce, including in the basic behavioral and social sciences. NIH's Next Generation Research Initiative has highlighted and increased support of ESIs generally, but increased efforts to build ESI capacity in targeted areas, including bBSSR, should be further pursued. Within specific areas of research, such as bBSSR, even small advances in the proportion of ESIs can make a significant difference. ESIs in bBSSR have benefited from NIDA's Behavioral Science Track Award for Rapid Transition (B/START) program (PAR-19-310; https://grants.nih.gov/grants/guide/pa-files/PAR-19-310.html), which uses the R03 mechanism to seed innovative affective, cognitive, and behavioral hypotheses, models, and methods in preclinical and clinical substance use research. Expansion and adoption of this initiative by other ICs would increase support for beginning bBSSR investigators and increase the pipeline of high quality ESI applicants in bBSSR. Expansion of the NIGMS Maximizing Investigators' Research Award (MIRA) program (PAR-20-117; https://grants.nih.gov/grants/guide/pa-files/PAR-20-117.html) for ESIs to more bBSSR investigators is another potential opportunity to strengthen the next generation workforce in the basic behavioral and social sciences.

   The behavioral and social sciences have been leaders in diversifying the gender and race/ethnicity of the scientific workforce. Of the various scientific disciplines assessed in a recent National Science Foundation (NSF) report, only psychology and the social sciences have a larger percentage of women than men, and this has been the case for nearly two decades.[4] In specific bBSSR disciplines, such as economics and political science, however, gender diversity remains a challenge.[3] Although the behavioral and social sciences need to continue to improve the racial and ethnic diversity of the workforce, the NSF report showed that the percentage of URMs in psychology and the social sciences had the largest increase among the

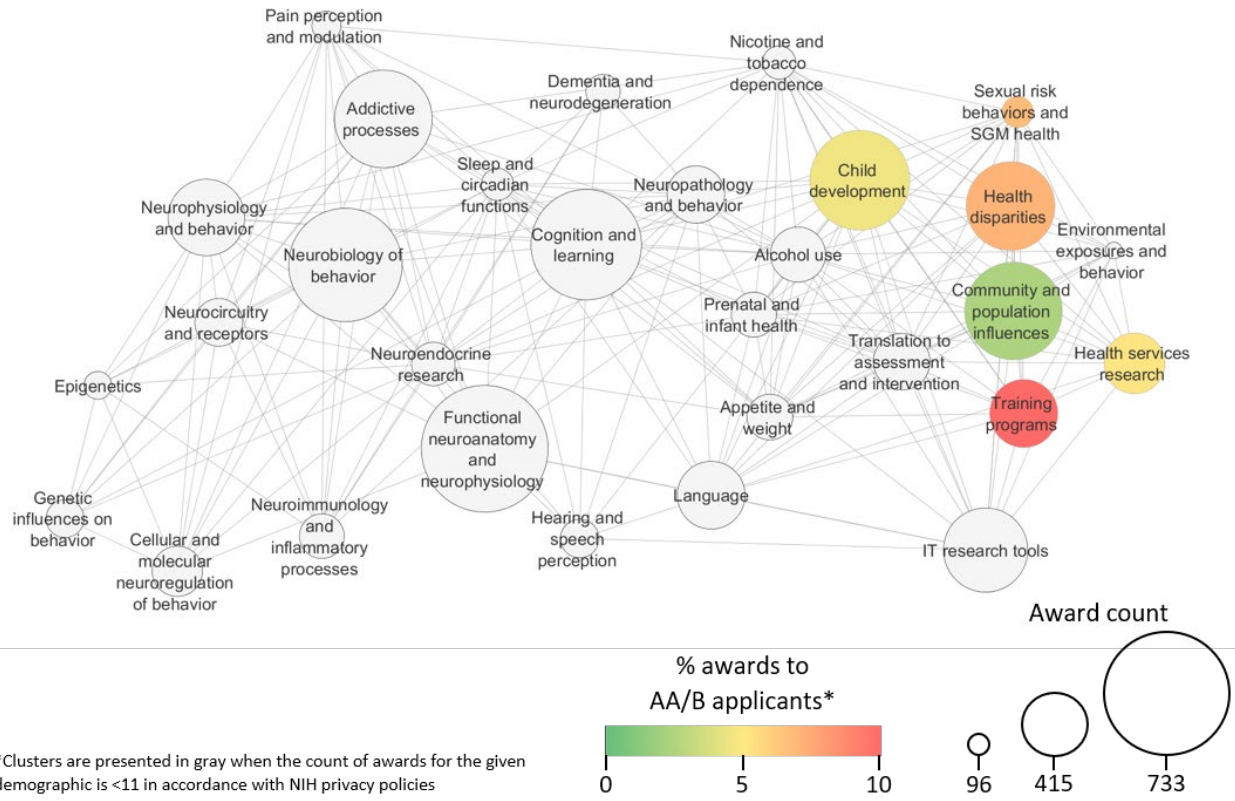
scientific disciplines assessed, increasing from 11 percent in 2003 to nearly 20 percent in 2017.

As a result of the strides made in workforce diversity by the behavioral and social sciences, one potential benefit of a robust bBSSR agenda at the NIH is increasing the diversity of NIH awardees. Recent research[5] has shown that topic choice is a significant contributor to the lower than expected rates of funding success among African American/Black (AA/B) investigators. AA/B applicants tend to propose research on topics with lower award rates, including research at the community and population level. This study noted that although AA/B investigators are underrepresented across all areas of research, they are less so among some of the areas of research included under bBSSR, particularly more social and population health research areas such as health disparities and community health.

The Black Women's Health Study follows a cohort of 59,000 Black women and has found that greater experiences of racism were associated with increased incidences of asthma, breast cancer, Type 2 diabetes, obesity, and prevalence of insomnia. Additionally, women who reported more frequent experiences of institutional racism had 2.66 times the risk of poor social cognitive function as those who reported no such experiences.[20] The many associations of racism-related chronic stress, disease, and impaired cognitive function suggest the need for basic research to determine discrete and synergistic biopsychosocial pathways between racism, cancer, chronic conditions, cognitive decline, and Alzheimer's and related dementia.

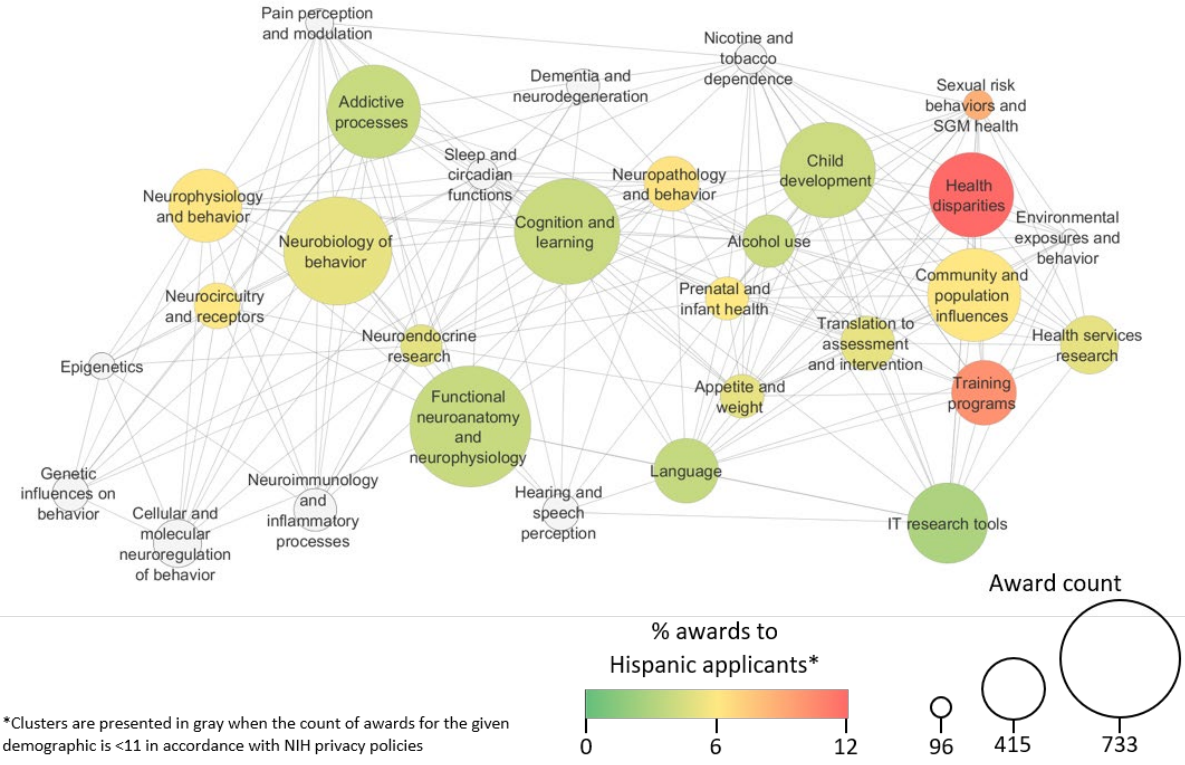
To understand the workforce diversity of the NIH bBSSR portfolio better, the working group asked OPA to assess the percentage of URMs by bBSSR cluster. Figures 6 and 7 show the distribution of AA/B principal investigators (PIs) and the distribution of Hispanic PIs by bBSSR cluster. The AA/B bBSSR PI pool is small and localized in six of the 30 clusters: training programs, health disparities, child development, sexual risk behaviors and SGM health, health services research, and community and population influences. Hispanic PIs have a similar pattern of research interest but are distributed across more of the clusters, including the more laboratory-based (left-side) clusters. A significantly (95% confidence interval) higher proportion of AA/B PIs were in the training, health services research, health disparities, environmental exposures and behavior, child development, and sexual risk behavior and SGM health clusters relative to the fraction of AA/B or Hispanic applicants in the overall bBSSR portfolio. With the exception of health services research and child development, Hispanic PIs had significant higher proportions for the same clusters. Therefore, an increased emphasis on bBSSR support by the NIH has the potential to increase scientific workforce diversity among NIH-supported, but the field must continue to address workforce diversity, particularly in the more laboratory-based areas of bBSSR in which URMs are most underrepresented.

Figure 6. NIH bBSSR awards to African American/Black applicants



*Clusters are presented in gray when the count of awards for the given demographic is <11 in accordance with NIH privacy policies

Figure 7. NIH bBSSR awards to Hispanic applicants



*Clusters are presented in gray when the count of awards for the given demographic is <11 in accordance with NIH privacy policies

One example of targeted efforts to encourage early-stage URM researchers to develop interests and skills in bBSSR areas most in need of workforce diversity is the BRAIN Initiative Advanced Postdoctoral Career Transitional Award to Promote Diversity (PAR-18-813; https://grants.nih.gov/grants/guide/pa-files/par-18-813.html). This initiative promotes retention and advances individuals from diverse backgrounds, including women, individuals from underrepresented racial and ethnic groups, and individuals with disabilities in BRAIN Initiative research careers, potentially including behavioral neuroscience, cognitive neuroscience, and social neuroscience. NIH Blueprint supports undergraduate diversity programs in neuroscience (https://neuroscienceblueprint.nih.gov/training/endure-undergraduate-education), and the d-SPAN program supports postdoctoral transition to encourage diversity (https://neuroscienceblueprint.nih.gov/training/nih-blueprint-d-span-award-f99k00). NINDS and other ICs also support F31s (PA-21-052; https://grants.nih.gov/grants/guide/pa-files/PA-21-052.html) and other predoctoral training programs that encourage diversity. Although these neuroscience-focused diversity training programs may increase bBSSR diversity as well, a more comprehensive diversity training program focused on the breadth of bBSSR topic areas has the potential to develop a more diverse bBSSR workforce. All basic and applied sciences supported by the NIH benefit from greater workforce diversity, but bBSSR has a particularly compelling need for workforce diversity due to the importance of considering social and cultural influences and contexts in this research. A heterogenous and diverse bBSSR workforce that reflects the breadth of social and cultural experiences strengthens the science and its implications.

Workforce diversity includes international diversity, and a need exists for increased capacity for institutions in low- and middle-income countries to conduct bBSSR. Fogarty International Center (FIC) has collaborated with OBSSR and the NIH ICs on a number of meaningful efforts to increase BSSR capacity internationally, but much of the BSSR of interest in developing countries tends to be applied. Basic research also should be encouraged in developing countries, and FIC and OBSSR should work together it identify opportunities to build research capacity in bBSSR.

2. *Strengthen workforce training and capacity building.* In addition to building the diversity of the bBSSR workforce, the working group noted several workforce capacity training needs that the NIH should consider, especially to accelerate emerging and promising areas of bBSSR research identified by the workgroup. OBSSR has supported training institutes on advanced methods and approaches for many years and recently launched a T32 program (Training in Advanced Data and Analysis for Behavioral and Social Sciences Research [TADA-BSSR]) that integrates data science and behavioral and social sciences training at the predoctoral level (RFA-OD-18-011; https://grants.nih.gov/grants/guide/rfa-files/RFA-OD-19-011.html). NIH ICs also support a range of training opportunities that include bBSSR capacity building. These training efforts are important, but as the research becomes increasingly sophisticated and complex, they will need to expand to include emerging methods and approaches. Among the areas of capacity building needs identified by the working group are:

2.1. *Increase data science capabilities.* Data science—particularly in data extraction, harmonization, integrative data analysis, and secondary data analysis methods, including computational and machine learning approaches—is needed for bBSSR investigators to extract maximum information from existing data with minimal bias and statistically dependent findings. As the NIH implements its Strategic Plan for Data Science,[21] bBSSR workforce capacity in this area should be addressed.

2.2. *Build capacity for assessing small populations with sufficient power*. Although big data is becoming increasingly important to bBSSR and other NIH research areas, some questions are unique to small populations. Rare diseases, small demographic groups, and other small populations are critically important to study, even if the size of the population challenges typical research approaches. Training in how to conduct research in these small populations to achieve sufficient power is needed.

2.3. *Expand understanding of causal inference beyond the randomized controlled trial (RCT).* RCTs may be the gold standard for causal inference, but this method is not the only standard, and there are important limitations to causal inference from RCTs that need to be better understood. In many cases, basic behavioral and social sciences researchers are unable to adequately control, manipulate, or isolate the independent variable of interest, especially in social systems. More sophisticated understanding of causal inference, including the use of various quasi-experimental designs and approaches that control confounds statistically, is needed. One of the OBSSR R25 training institute awards focused on causal inference training (https://reporter.nih.gov/project-details/9853989), and expansion of such training by OBSSR and the NIH ICs should be strongly considered.

2.4. *Expand T32s into more bBSSR areas*. Training needs should be considered across the career trajectory, including predoctoral T32s, pre- and postdoctoral fellowships (Fs), and various K awards, but the working group noted that many of the T32s funded by the NIH ICs seem to be biomedically-focused and tend to target the research training of M.D.s. These training goals are laudable, but bBSSR T32s appear to be a relatively small subset of the NIH T32 investment. An analysis of the bBSSR represented in the T32 programs should be considered, and specific training needs should be identified.

3. *Foster team science and transdisciplinary integration.* The findings from bBSSR are applicable across a wide range of research supported by the NIH. Greater integration with neuroscience, genetics, and animal/human research is specifically highlighted below, but bBSSR can and should be integrated more broadly across the NIH health research enterprise. From a translational perspective, bBSSR findings are applicable to a broad range of applied biomedical research, not just applied BSSR. For instance, recruitment and retention in clinical research are essentially a social and behavioral challenge, but clinical researchers seldom consider relevant bBSSR when devising strategies to promote recruitment and retention. HIV research is an excellent example of integrating behavioral research questions such as mechanisms of medication adherence, into biomedical studies. The failure to

incorporate bBSSR questions earlier and more substantially into biomedical research is a missed opportunity. For example, the NIH research response to the COVID-19 pandemic was urgent and extensive, but bBSSR could have been integrated earlier, including in initial vaccine trials to study vaccine hesitancy and in the initial therapeutic trials to study the psychosocial impacts of COVID-19 and its treatments, including the impacts of intensive care hospitalizations.

During the deliberations of this working group, another working group was chartered based on congressional report language to focus on BSSR integration. That new working group will consider in greater depth the potential opportunities to include behavioral and social science questions, both basic and applied, more often in biomedical research studies. The goal of that working group charter is consistent with our conclusion that greater inclusion of bBSSR questions in biomedical research is an efficient approach to expand the research impact of NIH biomedical research support.

3.1. *Strengthen the incorporation of basic behavioral and social sciences with neuroscience.* Many behavioral and social science disciplines have been rooted in the brain sciences since their inception, and over the past decade, we have seen exponential growth in neuroscience generally and in behavioral neuroscience, cognitive neuroscience, and social neuroscience in particular. The integration of neuroscience and bBSSR is already strongly represented in the bBSSR portfolio. As noted previously, although much of bBSSR is integrated with neuroscience, most of neuroscience is not integrated with bBSSR. Recent NIH investments in trans-NIH neuroscience efforts, such as Blueprint and the BRAIN Initiative, as well as many IC-specific investments, have the potential to advance the behavioral, cognitive, and social neurosciences as well, but to date these neuroscience efforts have funded a relatively small proportion of neuroscience integrated with the basic behavioral and social sciences. BRAIN 2.0 holds promise to strengthen this integration. For instance, the “Brain in Action” priority calls out the need to expand the ability to understand neuromodulatory function; tools to study larger (primate) brains; and sophisticated, computational tools to better assess behaviors (especially in natural settings) (https://braininitiative.nih.gov/strategic-planning/acd-working-groups/brain-initiative%C2%AE-20-cells-circuits-toward-cures). The BRAIN Initiative should make a concerted effort in BRAIN 2.0 to apply the innovative tools developed from BRAIN 1.0 not only to brain disease states but also to basic behavioral processes such as attention, learning, memory, and basic social processes such as attachment, empathy, and relationship formation.

Greater integration of neuroscience with developmental research also is needed. ECHO and ABCD are examples of recent developmental science efforts that have integrated neuroscience into the understanding of developmental processes, and the two “lifecourse development” ICs (NICHD and NIA) also have provided support for greater integration of neuroscience in developmental research. The working group, however, believes that this integration can be further strengthened, especially for understanding the

interplay of neurobiological and environmental processes that shape development throughout the lifespan. This integration is not the responsibility only of the lifecourse development ICs; the neuroscience-focused ICs should consider strengthening the integration of developmental processes more in the neuroscience research they support, especially since many of the disorders they study have long developmental prodromal periods.

This call for greater integration of the neurosciences and the basic behavioral and social sciences should not be construed as requiring that every neuroscience study have a behavioral or social phenomenon as its outcome or that every bBSSR study include neural measures. Each research area is valuable in its own right, and forced integration can lead to poor science if the research team is not skilled at assessing and manipulating variables relevant to both research areas. A brain scan should not be appended to a bBSSR grant application just to increase its chances of funding, and less use of brain imaging for descriptive purposes without mechanistic implications would be beneficial both to the neuroscience and bBSSR fields. It is a missed opportunity, however, for either bBSSR or neuroscience to propose a research study without adequately considering both the neurobiological and social/behavioral mechanisms relevant to the research question. With both trans-NIH and IC-specific initiatives, the NIH should encourage greater integration of bBSSR and neuroscience approaches.

3.2 *Encourage an expanded role for bBSSR in genetics research.* Initial efforts to integrate bBSSR in genetics research focused on the ethical and social implications of this research, genetics counseling, and other areas in which genetics impact social and behavioral phenomena. Over time, the role of bBSSR in genetics research has expanded to include sample diversity, behavioral genetics, and gene by environment interaction (GxE) research.

The underrepresentation of non-European ancestry in genetics studies is well established and gradually being addressed with more diverse ancestry samples. Obtaining diverse samples, however, is challenged by longstanding and often well-founded distrust among minority groups about how genetic materials and findings are misused. Improved understanding of this distrust is essential to obtaining more diverse genetic samples. Additionally, genomic research would benefit from more widespread recognition that health disparities are fundamentally and traditionally defined as products of social disadvantage. Recognition of the social environmental components that affect disease processes, therefore, is important to understanding genome function and trait diversity beyond obtaining more genetically diverse samples.[22] These perspectives and others from bBSSR could strengthen genetics research, but current NIH support for bBSSR relevant to genetics appears inadequate for this level of integration.

The NIH funds considerable research on how genetics influence the molecular pathways of disease. Less emphasized is how genetics influence the behavioral pathways of disease. Research on the role of genetics in predisposition to substance dependence is strongly represented in the

behavioral genetics research of NIH, but how genetics influence other behaviors that contribute to disease (e.g., decision processes, adherence to heath advice, stress resilience) is less well studied. Such research also strongly calls for well-powered GxE interaction research, which to date has been inadequate to characterize the complex and dynamic nature of environmental influences. Greater integration of behavioral genomic and GxE questions into large genomic studies is needed, which will require interdisciplinary contributions from both geneticists and researchers in the basic social and behavioral sciences with expertise in quantifying and analyzing behavior. Greater integration and sufficient resources will appropriately limit candidate gene studies of social and behavioral traits which provide minimal value to the field. The focus of this research should shift to substantive analyses of stability and more complex causal relationships that integrate genomic, environmental, and physiological data in large and sociologically diverse samples. This research direction may be best accomplished by integrating these behavioral and environmental influences more substantially into large existing genomic studies. Examining animal models of diverse genetic backgrounds may also be a productive avenue for further grounding bBSSR in genetics and animal research.

3.3. *Integrate knowledge generated through animal model and human subjects more readily.* Among the many translational challenges in bBSSR, the translation of animal research to human basic research needs to be strengthened. Animal research and animal models could be improved with a greater understanding of how this research may or may not be relevant to human behavior, especially in a social context, and basic research involving humans could benefit from being more strongly grounded in prior animal research relevant to the research question. Two approaches can be used to address this need. One is to increase the research support and training for multidisciplinary research teams and centers that conduct animal and human research in parallel to answer common research questions. The other is to increase the training of investigators working with animals to expand their research into humans or vice versa. OppNet has

> The relationship between the social environment and mortality risk has been known in humans for some time, but studies in other social mammals have only recently been able to test for the same general phenomenon. Animal models also have advanced our understanding of causal links between social processes and health. Laboratory animal studies indicate that socially induced stress has direct effects on immune function, disease susceptibility, and life span. Animal models have revealed pervasive changes in the response to social adversity that are detectable at the molecular level. Recent work in mice also has shown that socially induced stress shortens natural life spans owing to multiple causes, including atherosclerosis. This result echoes those in humans, in which social adversity predicts increased mortality risk from almost all major causes of death. These findings highlight the importance of the social environment to health and mortality and emphasize the utility of cross-species analysis for understanding the predictors of, and mechanisms underlying, social gradients in health.[23]

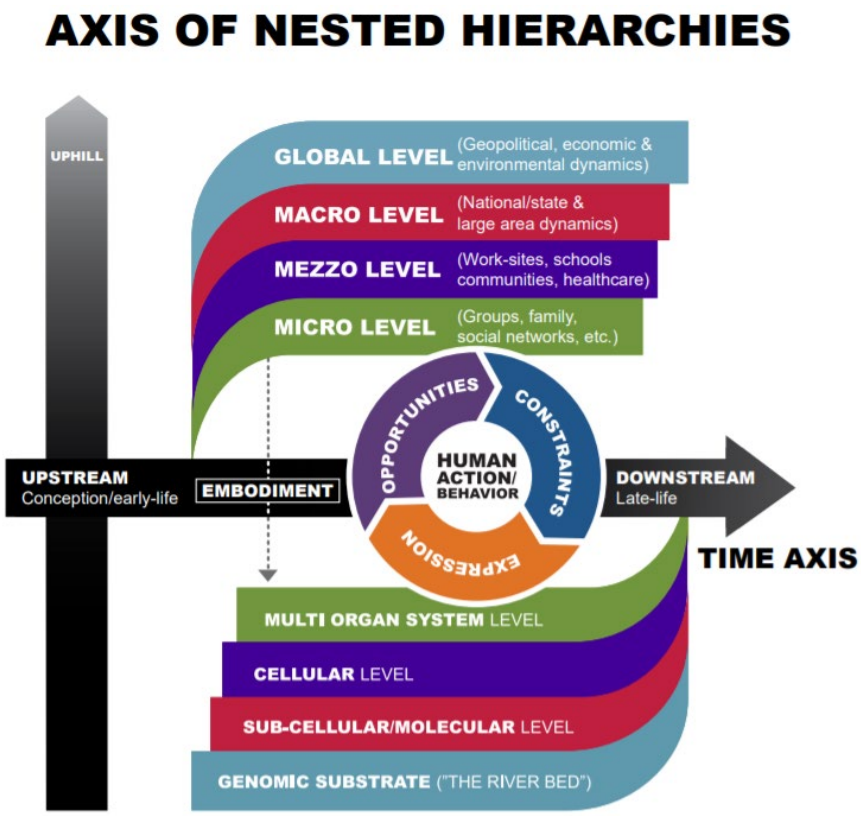
used a K18 award for this purpose, and strengthening that effort along with targeting support and training for research centers with both animal and human research components should improve the translation from animal to human research and back.[24]

3.4. *Support skills in interdisciplinary research and team science.* As bBSSR becomes increasingly integrated with biomedical, computer science, engineering, and other research areas, working in and leading transdisciplinary teams becomes increasingly valuable. Team science approaches and training led by NCI have strengthened this training effort (https://www.cancer.gov/about-nci/organization/crs/research-initiatives/team-science-field-guide), but greater involvement of basic social and behavioral scientists in such training is important to facilitate further collaboration and integration. Related to this training is the need for basic social and behavioral researchers to increase their skills at developing multicenter proposals and team-based studies.

4. Strengthen bBSSR infrastructure and processes. The working group considered the scientific approaches and infrastructure needs of bBSSR, both in the promising and emerging areas of bBSSR outlined previously as well as the overall bBSSR portfolio that the NIH currently supports. To strengthen the scientific approaches, infrastructure needs and the management of bBSSR at the NIH, the working group offers the following recommendations.

4.1. *Encourage more multilevel research.* Health over the life course is the result of a complex and dynamic interplay of multidimensional influences that range from genetic determinants to social, cultural, and environmental determinants. This confluence of multilevel influences is highlighted by the Glass and McEntee[25] in Figure 8 that serves as a basis for the OBSSR Strategic Plan. The NIH has supported a number of multilevel research FOAs, and these efforts should be continued, but often these multilevel studies are predominately intra-individual with a small inter-individual or social contextual component. The NIH should consider encouraging research in areas that require true multilevel data collection and analysis to address the question. For instance, studies of collective action to promote health require understanding the intra-individual dynamics for collective action, the social interactions needed to produce collective action, and the policy and community health outcomes as well as the individual health benefits of collective action. The role of climate change on health is another example that requires multilevel research to address. Environmental exposures and behavior, for example, represents the smallest cluster of bBSSR research supported by the NIH, but this is an area of research that typically requires multilevel research approaches. Regardless of the research topics chosen, encouraging research that requires multilevel research to accomplish may be more productive than generic encouragement for multilevel research.

Figure 8. Axis of Nested Hierarchies



4.2. *Strengthen basic-applied translational integration.* There is general agreement that translation of bBSSR to applied intervention research is insufficient, negatively affecting the development and evaluation of novel and innovative approaches to change behaviors and social systems relevant to health. The working group noted several efforts that the NIH could consider that would improve the translation of bBSSR and opportunities for applied BSSR findings that lead to basic research questions. Although not all bBSSR needs to be translational, plausible pathways to health applications should be demonstrated.

bBSSR needs to be more responsive to real-world problems. Some facets of bBSSR are driven primarily by top-down theoretical research. Such theoretically grounded research is important but needs to be balanced with more bottom-up, pragmatic, problem-focused research, or in Pasteur's Quadrant terms,[26] more use-inspired basic research that bridges the gap between pure basic and applied research. This more problem-focused perspective extends beyond the research question. Study participants should be drawn from relevant populations, not only from convenience samples (e.g., college students). Given the variety of representative online panels, patient registries, and recruitment channels, relevant generalizable samples are readily available. Measures and procedures should be more authentic and

grounded in real-world processes (e.g., semantic learning), not contrived or artificial procedures (e.g., nonsense syllable learning). Studies of only attitudes, perceptions, or beliefs without an overt behavioral or social outcome should be discouraged. Behavioral intentions are predictive of behavior,[27] but studies that do not link intentions to an actual authentic behavioral outcome limit translation. bBSSR FOAs targeted to practical problems should be useful in shifting the field to a more appropriate balance of theoretical versus problem-solving or use-inspired research. Relatedly, animal studies in ecologically valid environments that support natural behavior are needed for translatable bBSSR.

Analysis of the current bBSSR portfolio suggests greater support for basic research more distal to translation (e.g., basic neuroscience) than basic research more proximal to behavioral states and conditions, such as substance abuse and pain, can increase translation. Increased support by the ICs for basic research more directly relevant to the behavioral or disease states consistent with their mission should strengthen translation.

The Science of Behavior Change (SOBC) initiative was a successful demonstration of translating basic research into applied approaches. With the SOBC initiative transitioning from Common Fund support, OBSSR, the Office of Strategic Initiatives, and relevant ICs should work together to determine how to extend this translational model. NCATS has considerable expertise in biomedical translational research that could have important implications for the translation of bBSSR, and OBSSR and NCATS should partner more substantially to determine how to expand and accelerate translational research in the behavioral and social sciences.

Greater collaboration is needed between OBSSR and OPA to develop a translational analysis tool relevant to behavioral and social sciences. The current OPA translational tools are based predominantly on biomedical research in which human research is almost always applied, with cell and animal research representing basic research. In contrast, bBSSR involves minimal cellular research and some animal research, but most bBSSR is conducted with humans. The development of a portfolio analysis tool that will track the progression of translation from bBSSR to applied BSSR is essential for identifying those areas of bBSSR with versus without a plausible translational pathway. The working group noted that sensory processing and human spatial navigation are two areas of bBSSR that appear ripe for translation, but many other areas could be identified through a more dedicated OPA and OBSSR effort to track translation of bBSSR.

4.3. *Accelerate advances in epidemiology and population health approaches.* The prototypic image of basic research is often bench or laboratory-based research, but for the basic behavioral and social sciences relevant to health, epidemiologic and population health research are core foundational areas of basic research as well. The roles of demography, geography, community, and social systems are central to understanding health and illness, as evidenced by the increasing interest in the social determinants of health. The NIH has

provided considerable support for population health research. That support is particularly strong within a few ICs, such as NIA, NICHD, NCI, NIDA, and NHLBI, each of which have divisions or branches dedicated to these efforts. Other ICs may need to consider whether their population health research efforts are sufficient given the role of social and environmental factors on their disease-specific missions. In addition to IC-specific efforts, the NIH has made recent major investments in large-scale longitudinal cohort efforts, including ECHO, ABCD, and *All of Us*. Although these are large and diverse samples, none of these longitudinal cohorts are nationally representative, limiting the generalizability of their findings. Within these projects, a small probabilistic subsample could be obtained collecting the same data as for the full sample, which would provide the ability to weight the overall sample data based on the smaller probabilistic sample.

Retrospective survey responses have been the predominant method for collecting social and behavioral longitudinal cohort data. Although these methods remain a valuable and important component of population health research, technological and data science advances make it possible to assess behaviors and their contexts via smartphones, wearable and at-home sensors, the digital data from interacting on search engines and social media, and increasingly rich administrative data sets. These approaches provide temporally dense and ecologically valid assessments of daily experiences relevant to health. Greater use of these assessment techniques should be encouraged using targeted research support for epidemiological and population health research to validate and adopt these approaches.

Although cross-sectional and descriptive studies under conditions in which population-level data are limited or scarce have scientific value, repeated descriptive studies documenting phenomena that are already well documented, such as health disparities, provide minimal additional scientific value. Cross-sectional self-report research is of limited value in the absence of replication or confirmatory research and should not be used to infer causality. The NIH should prioritize longitudinal, mechanistically-driven research over cross-sectional and descriptive research unless there is a compelling scientific justification otherwise. Using advanced statistical approaches and targeted manipulations of putative mechanisms, population health research supported by the NIH should strive to make causal inferences whenever possible, not merely associational statements, about the role of social and behavioral phenomena on health. If a longitudinal approach is not possible, cross-sectional research should have key variables of interest assessed via modalities other than self-report and/or with planned replication and confirmation studies.

The NIH and other government research entities support a large and diverse array of epidemiological and population survey research. These epidemiological data sources need to be better integrated, and any new research should build from and link to these data sources and their procedures whenever possible. These population survey efforts are vast and

insufficiently integrated with one another, resulting not only in challenges for data comparisons, data sharing, and data integration, but also for identifying key population health questions not adequately addressed by existing efforts. The NIH and other government agencies already coordinate activities in this area to some degree and provide support for survey repository infrastructures, such as the Inter-University Consortium for Political and Social Research (ICPSR; https://www.icpsr.umich.edu/web/pages), to address this issue, but more needs to be done to improve the interconnectedness, integration, and coordination of the many epidemiological and survey research efforts supported by various government research entities. A coordinated effort across agencies, with sufficient funding, would fill a critically important research infrastructure need in epidemiology and population health research.

4.4. *Expand support for the collection of large bBSSR data repositories and resources.* Epidemiology and population survey research is only one of many bBSSR areas in need of stronger data integration and data repository resources. In contrast to basic biomedical research, bBSSR has limited shared data resources to facilitate and accelerate this research. There is a dearth of large, reusable, high quality bBSSR data sets, and resources are insufficient to identify, access, and connect or integrate relevant databases. Increasing these resources would facilitate data integration and analysis, not only by increasing sample size with broader and more representative samples, but also by analyzing methods variation between studies that could affect replication.

Creating such resources could be achieved in several ways, including the following:

4.4.1. Enhance and expand ICPSR and similar data repositories in the population sciences area with bBSSR data. Data from other agencies can be made more accessible. The agreement between NIH and the National Center for Health Statistics National Death Index (NDI) is one positive effort to make government agency data more readily accessible to NIH-supported researchers, but much more needs to be accomplished, especially as administrative datasets increase and become increasingly important in population health research.

4.4.2. *Enhance existing NIH data repositories with more bBSSR-relevant data.* For instance, *All of Us* holds considerable promise for obtaining a range of behavioral, social, and community-level data that could be leveraged by basic behavioral and social science researchers. Thus far, however, *All of Us* appears to have focused its research data collection primarily on genetics and electronic health records and less on data from self-report, smartphone, sensor, and administrative data sets that would be of particular value to basic behavioral and social sciences researchers.

4.4.3. *Enhance social science data repositories with more health data.* A complementary effort to enhancing health-focused data repositories with more social and behavioral data is to enhance social and behavioral

science data repositories with more health-relevant data. The Panel Study of Income Dynamics (PSID; https://psidonline.isr.umich.edu), for example, could be augmented to include key health outcome data. Such an effort would require collaboration between NSF and the NIH to support this enhancement.

4.4.4. *Encourage greater data sharing among laboratory or experimental bBSSR.* Although much more progress is needed, population health has begun to transition to more open access and shared data repositories. Laboratory or experimental bBSSR data also need to be shared, merged, and integrated into larger data repositories. Neuroscience efforts for sharing brain imaging are beginning to change the data sharing culture of bBSSR. Standardization of imaging data is an important step toward greater integration of behavioral, cognitive, and social neuroscience data, but NIH-supported laboratory-based researchers also should be encouraged to share data and provided the tools to assist in combining data from relevant laboratories in meaningful ways. The NIH Toolbox provides one resource for common measures and metrics assessing sensory, motor, cognitive, and emotional domains, but many laboratory-based procedures remain unique to each laboratory and are difficult to integrate. Guidance on how to document human subject characteristics from these laboratory-based samples also is needed. Overall, training and support for adoption of open science practices ranging from sharing data and analysis code to preregistration and sharing of open-access pre/postprints will increase the impact and rigor of bBSSR.

4.4.5. *Support data sharing and integration specifically.* The NIH R mechanism seems inadequate to support the development, curation, and maintenance of centralized data resources. Mechanisms specifically designed to support research resources in the biomedical field should be used to build similarly large, reusable data repositories in the bBSSR field. Because such research resources benefit bBSSR in all the NIH ICs, a trans-NIH effort is likely needed and should be a high priority for the NIH to create.

4.5. *Strengthen trans-NIH bBSSR initiatives and coordination with NIH ICs and with the NSF.* Most of the bBSSR funded by the NIH is supported by a few ICs. Four ICs (NIMH, NICHD, NIDA, NIA) each supported more than 1000 of the 10,000+ bBSSR grants awarded from 2008 through 2019, and three more (NINDS, NIAAA, NIDCD) funded between 500 and 1000 grants during this period. In contrast, over half of the NIH ICs fund very little bBSSR. Five ICs (NICHD, NIA, NCI, NIMHD, NHLBI) fund more non-neuroscience-related bBSSR than neuroscience-related bBSSR. bBSSR is clearly more central to the missions of some ICs than others, but this imbalance could limit translation, especially for the ICs that support applied BSSR but rely on other ICs to generate the foundational research needed to advance their applied BSSR agenda.

Some of the future directions for bBSSR outlined in this report are best addressed by specific ICs that currently fund a relatively small amount of bBSSR. For example, environmental exposure and behavior research

represents the smallest cluster of bBSSR funded by the NIH. OBSSR could collaborate with the National Institute of Environmental Health Sciences (NIEHS) on how to expand this research portfolio. Pain perception and modulation also is a smaller cluster of bBSSR that could be bolstered either by the NIH HEAL initiative or by the ICs most focused on pain research (e.g., NINDS, NIAMS). Basic research on social and behavioral influences on infectious disease transmission and mitigation could be strengthened with a greater emphasis on this research area by NIAID. Therefore, one consideration of each NIH IC, especially those with low levels of current bBSSR funding, is to assess whether their current efforts are adequate to address the bBSSR needs relevant to their respective missions. OBSSR should assist these smaller bBSSR ICs to identify specific bBSSR areas highly relevant to their missions.

Many of the priorities outlined in this report are trans-NIH in nature and relevant to many IC missions while also not being a clear priority for any one IC. As a result, a strong trans-NIH structure for direction, coordination, and support is needed. OppNet provided a productive but temporary structure for this trans-NIH bBSSR, but with the transition from required to voluntary support, it does not have sufficient resources or influence to encourage the bBSSR priorities described in this report. OppNet currently supports its initiatives with a $2 million total (new and outyear) commitment from OBSSR that is matched by participating ICs. This level of commitment is essentially the cost of a single 5-year R01 grant, which is inadequate to develop and support even one of the trans-NIH bBSSR priorities outlined in this report.

OppNet's current voluntary participation and support for initiatives is essentially the same as OBSSR's approach for developing and leading trans-NIH initiatives more broadly. This process involves identifying interested ICs and collaborating with these ICs to generate sufficient financial commitments to develop and fund a new trans-NIH initiative. In the absence of a dedicated financial commitment to OppNet, much of its current efforts can be subsumed under the general functions of OBSSR. OBSSR, however, needs to leverage its limited budget to encourage ICs to contribute to trans-NIH bBSSR efforts they agree are mutually beneficial to pursue. Some of the bBSSR priorities outlined in this report may be achievable from a reshuffling of bBSSR priorities within ICs alone, but many of these priorities will require trans-NIH OD leadership and financial support. Therefore, whether NIH leadership chooses to subsume OppNet functions under OBSSR or not, there appears to be a need for greater NIH leadership support for bBSSR. One option would be to create a trans-NIH bBSSR effort similar to Blueprint in which the leadership of relevant ICs organize to address trans-NIH bBSSR priorities, consider contributing to a pool based on the proportion of bBSSR that they fund, and determine how these pooled funds should be spent on which initiatives, augmenting the funding pool with additional voluntary contributions as needed. Regardless of model, a bBSSR leadership advisory group composed of IC leadership that meets periodically to consider future directions and funding for trans-NIH bBSSR initiatives that are sufficiently relevant to their IC missions would strengthen trans-NIH bBSSR direction.

The working group also noted that the other agency that provides considerable support for bBSSR is the NSF, specifically the Social, Behavioral, and Economics (SBE) Directorate. There are considerable advantages for the bBSSR community, as well as for the NIH and NSF, to increase collaboration. NSF and NIH have shared but complementary interests in bBSSR. Researchers who straddle the interests of these two funding agencies must navigate very different grant application, review, and funding procedures; therefore, efforts to resolve unnecessary differences in the grant application and award process of these two agencies can facilitate bBSSR funded by the two agencies. To better coordinate activities, one function of the NIH bBSSR leadership advisory group described above could be to meet periodically with the NSF SBE leadership, compare research funding over the prior year, resolve any areas of possible overlap, and consider potential collaborative initiatives beneficial to both agencies.

Conclusion

bBSSR is more strongly supported at the NIH than ever before, and the bBSSR research supported by the NIH has and will continue to advance the science in meaningful ways and address some of the most pressing public health issues of our time. This report identified a number of promising, emerging, and currently understudied areas of bBSSR that should be strengthened:

- Specific behavioral, cognitive, and social neuroscience areas, such as event representation and brain-body integration
- Epigenetics
- Basic functions, such as sleep and sex
- Infectious disease relevant bBSSR
- Social interactions and health
- Behavioral maintenance
- Positive health processes
- Science of science

This report highlights the need for increased workforce diversity within bBSSR, particularly in more laboratory-based bBSSR areas by AA/B investigators. Many of the NIH-wide workforce diversity efforts likely will benefit bBSSR workforce diversity as well, but the need for diversity in bBSSR is particularly crucial given the cultural and contextual influences on behavioral and social phenomena. The report also highlights areas in need of capacity building in bBSSR, including data science, small population research, and causal inference.

A number of recommendations are made in this report about how to improve and accelerate bBSSR. Greater integration of bBSSR with the larger NIH biomedical

research effort, specifically with neuroscience and genetics, is needed, and a subsequent Council of Councils working group focused on behavioral science integration should address this issue in more depth. bBSSR funded by the NIH also could benefit from more multilevel research, approaches that improve translation, efforts to accelerate epidemiology and population health advances, and more data repository and data integration resources.

NIH bBSSR is a combination of IC-relevant areas of research and trans-NIH bBSSR relevant to the missions of many ICs. A strong trans-NIH bBSSR coordination function with strong NIH leadership involvement, particularly from the ICs with considerable bBSSR support, is needed to maintain NIH's support for core bBSSR areas and address the recommendations of this report. bBSSR is a critical component of the NIH mission to seek fundamental knowledge about the nature and behavior of living systems and the application of that knowledge to enhance health, lengthen life, and reduce the burdens of illness and disability.

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Appendix A. Summary of the 2004 Advisory Committee to the National Institutes of Health Director Basic Behavioral and Social Sciences Research Working Group Report and OppNet Funding Activities and Evaluation Results

Basic behavioral and social sciences research (bBSSR) furthers the understanding of fundamental mechanisms and patterns of behavioral and social functioning, relevant to the nation's health and well-being, and as they interact with each other, with biology and the environment. In the early 2000s, concerns were raised about the National Institutes of Health (NIH) commitment to bBSSR, leading to discussions between the NIH and various stakeholders about the status of bBSSR and the potential of expanding the scope of bBSSR across the NIH on topics including, but not limited to, "basic behavioral research and training" and "basic research to integrate physiological knowledge of pre-disease pathways with behavioral studies." This discussion also considered that most NIH Institutes, Centers, and Offices (ICOs) focus on diseases or somatic components and that a "home" for bBSSR should be considered.

To address these issues, the Advisory Committee to the NIH Director (ACD) convened a working group in 2004 to review the agency's bBSSR portfolio, examine potential barriers to the submission and review of applications in this area, identify opportunities for new bBSSR topics, and make recommendations to improve NIH's program in bBSSR. This working group conveyed two main findings:

1. The bBSSR programs that are currently functioning well within Institutes and Centers (ICs) should continue in their present form. Efforts should be made to encourage basic behavioral and social science researchers whose research is applicable to specific diseases, conditions, or developmental periods to seek support from the relevant ICs.
2. A secure and stable home at the NIH is needed to foster bBSSR that is not closely aligned to the missions of any one of the categorical Institutes and Centers, requiring staff with appropriate expertise and budget sufficient for the task. Such a home could facilitate bBSSR findings across health- and disease-specific contexts and also enhance the translation of basic to applied research in the behavioral and social sciences at the NIH. To complement the National Institute of General Medical Sciences training role that includes the basic behavioral sciences, the report suggested that the Office of Behavioral and Social Sciences Research (OBSSR) could follow an organizational model similar to the Office of AIDS Research (OAR) with increased planning and budget authority that would allow OBSSR to conduct continuous portfolio analyses in bBSSR and develop specific priorities or funding opportunity announcements (FOAs) in collaboration with IC-based program directors and extramural research community. As this "top-down approach to encouraging basic behavioral and social science research. . . would necessitate an increase in the staffing and funding for OBSSR, the Working Group recommends that NIH seek appropriations from Congress for this purpose" (ACD Working Group Report,[2] p. 12).

Although the working group did not specify future bBSSR priorities, it provided an extensive list "of opportunities that are ultimately likely to make important contributions to understanding and improving health outcomes," within six themes: Early Development; Gene-Environment Interactions; Macro-Social Behavior, Perception, Learning, Emotion, and Cognition; Social and Interpersonal Behavior; and Technology, Measurement and Methodology. In addition, the report stated, "These opportunities also demand studies of the biological mechanisms involved," and that have profound crosscutting implications for research on health disparities, obesity, diabetes, mood/affective disorders, and effects of early-life events on health over the lifecourse.[2,26]

Summary of OppNet Program

To address the trans-NIH bBSSR needs outlined in the report and achieve progress in bBSSR across the NIH, NIH leadership agreed to create the NIH Basic Behavioral and Social Science Opportunity Network (OppNet) as a 5-year collaborative financial and intellectual effort among all ICOs "to advance basic behavioral and social science research (bBSSR) through activities and initiatives that build a body of knowledge about the nature of behavior and social systems. OppNet prioritizes activities and initiatives that focus on basic mechanisms of behavior and social processes that are relevant to multiple NIH ICO missions and public health challenges and that may build on, but do not replicate, existing NIH investments."[28] In other words, OppNet was not a response to the Working Group's call for a structural change to OBSSR or any other NIH IC; rather, OBSSR functionally supported an inclusive trans-NIH initiative with a unique Congressional (Recovery Act) appropriation in its first year and dedicated support from all of the ICs in years 2 through 5.

Between fiscal years (FYs) 2010 and 2014, OppNet provided approximately $64 million to 152 discrete extramural research projects through 19 requests for applications (RFAs) and four notices that allowed investigators to apply for additional funds to incorporate new bBSSR specific aims and research objectives into non-OppNet–funded awards. (A complete list of OppNet Initiatives is provided below.) OppNet's concept-development process for FOAs originated from many different sources including the December 2004 Working Group report, responses from a January 2010 request for information (RFI), and a public workshop in October 2010, as well as ongoing portfolio and gap analyses. FOAs were created from these original materials, developed by program-level staff across the NIH, approved by a Steering Committee composed of the Director of each participating IC or his/her designee, cleared by a Coordinating Committee of bBSSR program staff, and approved by an ICO-Director-member Steering Committee that also set OppNet strategy and priorities. During this period, OppNet funding came from Recovery Act monies in FY 2010 and, in FY 2011–2014, allocations from NIH ICs based on a percentage of each IC's total extramural research budget. ICs also funded additional projects that matched program priorities when these awards were beyond OppNet's ability to award.

Within the 5-year timeframe of dedicated support, OppNet was productive and responsive to its mission. One example of OppNet's fulfillment of its mission to "build

on" existing bBSSR investments is the percentage of first-time NIH principal investigators (PIs)—54 percent—funded by OppNet. Some of these first-time awardees were early-stage investigators (ESIs), whereas others were more established investigators previously funded by other agencies (e.g., National Science Foundation) who transitioned their research to be more in line with NIH's health mission. Approximately a third of the new R01 and R21 OppNet grantees subsequently received NIH funding from the ICs to continue their research.

Publications constitute a second example of OppNet productivity. OppNet's 391 publications at the time of the evaluation had 5,630 citations. The median Relative Citation Ratio (RCR) for OppNet R01 and R21 publications was 2.44 and 2.63, respectively, compared to 1.36 for non-OppNet bBSSR R01 publications and 1.38 for R21 publications.[29]

A third example of OppNet's success was the support of bBSSR training. OppNet issued multiple K18 FOAs and funded 27 PIs throughout its first 5 years. Eleven of these K18 PIs (41%) received 13 subsequent NIH awards linked to their OppNet K18 awards.[29,30]

An independent evaluation of OppNet by a Federally Funded Research and Development Center recommended that the NIH continue OppNet and its unique FOA-development process, but that it should emphasized the initiation or seeding of new bBSSR domains, the development of new bBSSR investigators, and continue its focus on basic mechanisms of behavior and social processes and on building upon existing NIH bBSSR investments without replicating them.[29] These recommendations continue to guide OppNet activities.

After the 5 years of dedicated support, OppNet transitioned to voluntary support and participation by the ICs. OBSSR commits up to $2 million in matching funds each year, and participating ICs on OppNet FOAs have the option to fully fund an award or utilize the OBSSR matching funds to assist in supporting awards. Though all NIH ICOs may participate in concept development, ICO participation in published FOAs is optional. For example, six ICs participate with OBSSR in the OppNet K18 on mid-career enhancement awards to integrate behavioral, biomedical, and/or social scientific processes, and 14 ICs participate in the R01 Notice of Scientific Interest (NOSI) on biopsychosocial factors of social connectedness and isolation on health, wellbeing, illness, and recovery.

OppNet RFAs and Notices, FY 2010–2014

Six RFAs for R01 awards

- *Title*: Effects of the Social Environment on Health: Measurement, Methods and Mechanisms (R01) (RFA-DA-11-003). *Purpose*: to investigate structural, behavioral, sociocultural, environmental, cognitive, emotional, and/or biological mechanisms through which the social environment affects health outcomes.

- *Title*: Sleep and Social Environment: Basic Biopsychosocial Processes (R01) (RFA-HD-11-101). *Purpose*: to investigate the reciprocal interactions of the processes of sleep and circadian regulation and function with behavioral and social environment processes.
- *Title*: Psychosocial Stress and Behavior: Integration of Behavioral and Physiological Processes (R01) (RFA-HL-11-033). *Purpose*: to investigate multiple and potentially bidirectional pathways underlying the link between psychosocial stressors and behaviors that may ultimately impact biological function, health, and disease.
- *Title*: Basic Mechanisms Influencing Behavioral Maintenance (R01) (RFA-HL-11-035). *Purpose*: to advance research on basic processes and mechanisms involved in sustaining learned behavior over time and in the context of dynamic environmental influences and changing psychological and biological states.
- *Title*: Mechanistic Pathways Linking Psychosocial Stress and Behavior (R01) (RFA-HL-12-037). *Purpose*: to facilitate investigation of multiple and potentially bidirectional pathways underlying the behavioral, environmental, and psychosocial link(s) between psychosocial stressors and behaviors that may ultimately impact biological function, health, and disease.
- *Title*: Basic Research on Decision Making: Cognitive, Affective, and Developmental Perspectives (R01) (RFA-MH-12-130). *Purpose*: to increase understanding of the basic cognitive, affective, motivational, and social processes that underlie decision making across the lifespan.

Six RFAs for R21 awards

- *Title*: Basic Research on Self-Regulation (R21) (RFA-AG-11-010). *Purpose*: to advance research on basic processes and mechanisms of self-regulation.
- *Title*: Basic Behavioral Research on Multisensory Processing (R21) (RFA-EY-13-001). *Purpose*: to investigate multisensory processing (projects focused on two or more sensory modalities) in perception or other behavioral and social outcomes.
- *Title*: Sleep and Social Environment: Basic Biopsychosocial Processes (R21) (RFA-HD-11-102 *reissued as* RFA-HD-12-204). *Purpose*: to investigate the reciprocal interactions of the processes of sleep and circadian regulation and function with behavioral and social environment processes.
- *Title*: Sleep and Social Environment: Basic Biopsychosocial Processes (R21) (RFA-HD-12-204). FOA *Purpose*: *See RFA-HD-11-102 directly above*.
- *Title*: Development of Comprehensive and Conceptually-based Measures of Psychosocial Stress (R21) (RFA-HL-11-034). *Purpose*: to develop and test conceptually-based and comprehensive measures of psychosocial stress that can be applied across species and across the lifespan.

- *Title*: Research on the Role of Epigenetics in Social, Behavioral, Environmental and Biological Relationships, throughout the Life-Span and across Generations (R21) (RFA-TW-13-002). *Purpose*: to lay the foundation for innovative and collaborative basic research on the role of epigenetics in social, behavioral, environmental and biological relationships, throughout the life-span and across generations.

Three RFAs for K18 Research Career Enhancement awards

- *Title*: Recovery Act Limited Competition: NIH Basic Behavioral and Social Science Opportunity Network (OppNet) Short-term Mentored Career Development Awards in the Basic Behavioral and Social Sciences for Mid-career and Senior Investigators (K18) (RFA-OD-10-003). *Purpose*: to support the development of research capability in bBSSR of established, mid-career and senior investigators.
- *Title*: NIH Basic Behavioral and Social Science Opportunity Network (OppNet) Short-term Mentored Career Development Awards in the Basic Behavioral and Social Sciences for Mid-career and Senior Investigators (K18) (RFA-DE-11-003). *Purpose*: to support the development of research capability in bBSSR of established, mid-career and senior investigators.
- *Title*: Short-term Mentored Career Enhancement Awards in the Basic Behavioral and Social Sciences: Cross-Training at the Intersection of Animal Models and Human Investigation (K18) (RFA-DA-14-002). *Purpose*: to support development of research capability in bBSSR, with specific emphasis on cross-training and establishing collaborations between researchers with expertise in animal models of basic behavioral and social processes and those studying similar or related processes in human subjects.

One RFA each for supplements to R01 awards, workshop awards (R13), research resource awards (R24), and research education awards (R25)

- *Title*: Limited Competition: Revision Applications for Basic Social and Behavioral Research on the Social, Cultural, Biological, and Psychological Mechanisms of Stigma (R01) (RFA-MD-13-005). Purpose: to incorporate basic research on behavioral and social mechanisms underlying stigma into active R01 research projects.
- *Title*: Scientific Meetings for Creating Interdisciplinary Research Teams in Basic Behavioral and Social Science Research (R13) (RFA-CA-10-017). *Purpose*: to solicit applications for scientific meetings aimed at building interdisciplinary research teams in basic behavioral and social science research (bBSSR).
- *Title*: Basic social and behavioral research on culture, health, and wellbeing (R24) (RFA-LM-12-002). *Purpose*: to provide grants for infrastructure support to develop, strengthen, and evaluate transdisciplinary approaches and methods for

basic behavioral and/or social research on the relationships among cultural practices/beliefs, health, and well-being.

- *Title*: NIH Basic Behavioral and Social Science Opportunity Network (OppNet) Short-term Interdisciplinary Research Education Program for New Investigators (R25) (RFA-NR-11-002). *Purpose*: to provide creative and innovative education research experiences for new scientists in basic behavioral and social science research (bBSSR).

Four Notices for additional funds to incorporate new bBSSR specific aims and research objectives into non-OppNet–funded awards

- *Title*: Recovery Act Funds for Competitive Revision Applications (R01, R03, R15, R21, R21/R33, and R37; NOT-OD-10-032) through the NIH Basic Behavioral and Social Science Opportunity Network (OppNet)
- *Title:* Recovery Act Funds for Competitive Revision Applications (R01, R03, R15, R21, R21/R33, and R37; NOT-OD-10-033) for HIV/AIDS-related Research through the NIH Basic Behavioral and Social Science Opportunity Network (OppNet)
- *Title:* Recovery Act Funds for Competitive Revision Applications for Small Business Innovation Research and Small Business Transfer Technology Research Grants (R43/R44 and R41/R42; NOT-OD-10-034) through the NIH Basic Behavioral and Social Science Opportunity Network (OppNet)
- *Title:* HIV/AIDS Funds for Competitive Revision Applications (R01, R03, R15, R21, R21/R33, R37; NOT-OD-10-036) for HIV/AIDS-related Research through the NIH Basic Behavioral and Social Science Opportunity Network (OppNet)

Appendix B. Working Group Process

The Basic Behavioral and Social Sciences Research (bBSSR) Working Group of the Council of Councils held six meetings from September 2020 through May 2021. Initial meetings reviewed an overview of bBSSR and OppNet efforts across the National Institutes of Health (NIH) since the 2004 report on bBSSR at the NIH, and data from the Office of Portfolio Analysis (OPA) on topic clusters of bBSSR by applications, grants, award rates and other metrics. The analyses from OPA began in the summer of 2020 and focused on all NIH competing research program grants (RPGs) identified as Basic Behavioral and Social Science in the Research, Condition, and Disease Categorization (RCDC) system. The topic analyses started with a portfolio bound by the Basic Behavioral and Social Science RCDC term, limited to fiscal years (FYs) 2008 to 2019, only RPGs, and type 1 and 2 awards, which resulted in a total of 10,524 awards. The total costs for these awards were adjusted to FY 2019 dollars using the Biomedical Research Development Price Index (BRDPI). Next, the awards were analyzed with artificial intelligence and machine learning with the tool word2vec$_{OPA}$ analyzing titles, abstracts, and specific aims of awards. The awards in this analysis were limited to FYs 2015 to 2019 and sorted into 30 clusters, which is the recommended optimal number of clusters confirmed by silhouette analysis. Working group members discussed the implications of the portfolio analyses and asked for refinements as identified.

Because many of the working group members are editors or associate editors of major bBSSR journals, the working group addressed its charge by discussing the following questions from a journal editor and reviewer perspectives as well as a researcher perspective.

1. Name a specific area of basic behavioral and social sciences research that you would be excited about considering in review, either as a grant application or a manuscript for publication.

2. Name a specific area of basic behavioral and social sciences research that you would NOT be excited about considering in review, either as a grant application or a manuscript for publication.

3. Name a specific area of basic behavioral and social sciences research that you wish you would get more submissions to review, either as a grant application or a manuscript for publication.

4. Name a specific area of basic behavioral and social sciences research that you think shows strong promise for future clinical or public health applications.

5. Name a specific area of basic behavioral and social sciences research that you have seen submitted for years for review as a grant application or manuscript for publication that doesn't seem to have a plausible pathway to future clinical or public health applications.

Working group members asked for input from NIH program officers managing bBSSR portfolios. To obtain their responses, NIH staff implemented a crowd-sourcing campaign with modified versions of these questions from a funding perspective listed below.

1. Name one area of basic behavioral and social sciences research that your Institute or Center (IC) is excited about funding (i.e., your IC would be willing to skip better- scoring grants to fund this sort of research).

2. Name one area of basic behavioral and social sciences research that your IC is not excited about funding (i.e., your IC would skip grants in this area to fund other grants).

3. Name one area of basic behavioral and social sciences research that you wish your IC would get more grant applications on (e.g., a promising area that you don't see that much of coming into your IC).

4. Name one area of basic behavioral and social sciences research that you think shows strong promise for future clinical or public health applications.

5. Name one area of basic behavioral and social sciences research that your IC has been funding for years but doesn't seem to have a plausible pathway to future clinical or public health applications.

The crowd-sourcing program posted the questions to a platform, IdeaScale, where the program officials could respond anonymously or with attribution for 4 weeks. The crowd-sourcing campaign was advertised to program officials in several ways:

1. Via an email invitation for participation to the Program Leadership Committee and their full program official listserv

2. Via a follow up email to all program officials listed with any bBSSR grant (identified via the Basic Behavioral and Social Sciences RCDC term) in the last two fiscal years.

3. Via announcement at the NIH Behavioral and Social Sciences Research Coordinating Committee membership

However, despite this extended time for the campaign and promotion, only 11 responses from NIH program staff were received representing six ICs and one Office of the Director office. The team concluded a lack of familiarity with the tool among program officials and confusion about the types of responses requested (personal opinions and not official responses on behalf of the Institutes, Centers, or Offices [ICOs]) may have contributed to the poor response.

Considering the lack of engagement of the crowd-sourcing program, this effort was followed-up with two town halls with program staff. The town halls were promoted on the full NIH all staff listserv and the previously mentioned program officer listserv, and all program staff were encouraged to participate. Fifty-five program staff attended and were

given the opportunity to provide input between the two town halls. These staff represented at least 20 ICOs (some staff did not give enough information to identify their ICO affiliation). A full list of program staff by ICO is summarized below. A summary of the input provided by program officers through both the crowdsourcing and town hall input processes were provided to the working group members for a facilitated discussion.

Institute, Center, or Office	Number of Participants
CSR	1
NCATS	1
NCCIH	1
NCI	10
NEI	1
NHGRI	2
NHLBI	1
NIA	1
NIAAA	1
NIAMS	3
NICHD	4
NIDCR	4
NIEHS	1
NIGMS	1
NIMH	3
NIMHD	2
NINDS	1
NINR	2
NLM	3
OD	5

This report is based on the overviews, presentations, data, and other materials provided to the working group, the input from bBSSR program officers, and the expertise and experience of the working group members to identify emerging and promising priorities for NIH-supported bBSSR.