NIH Science of Behavior Change

Bethesda, Maryland
June 15-16, 2009

MEETING SUMMARY

National Institutes of Health

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Executive Summary

Because behavior has large and pervasive effects on health outcomes, better understanding of the mechanisms underlying behavior change promises substantial improvements in public health as well as savings in healthcare costs. For these reasons, advancing the science of behavior change has been identified by National Institutes of Health (NIH) Institute directors as a top priority for NIH-wide research efforts, and interest has been building to bring together scientists from a wide range of disciplines to radically move this science forward. The NIH meeting on the science of behavior change, held June 15 to 16, 2009, in Bethesda, Maryland, represented the coalescing of efforts to help the NIH shape an exciting new research agenda for a cross-NIH, cross-disciplinary initiative on the basic science of behavior change. Over 130 participants attended the meeting, including 60 invited experts who shared their perspectives from fields as varied as psychology, neuroscience, economics, sociology, nursing, biology, medicine, health behavior and health education, public health, epidemiology, gerontology, pharmacology, dentistry, marketing, communication, decision making, computer science, and engineering, as well as 67 NIH staff drawn from 17 Institutes and the offices of the NIH Director. The issues and ideas put forth by meeting participants stimulated innovative thinking and new collaborations aimed at accelerating the transformation of health promotion and disease prevention.

AGENDA FORMAT

The overall meeting format featured three panels designed to address key areas of behavior change science—namely (1) acquisition and prevention of behavior, (2) changing existing behaviors, and (3) maintenance of behavior—followed by a breakout session intended to promote integration and develop ideas for future research directions. Each panel was asked to address specific questions about basic social, behavioral, psychological, or neurobiological mechanisms and processes; individual differences that may enhance resiliency and the ability to resist adoption of unhealthy behaviors; whether there are particular developmental windows of vulnerability that may disrupt critical periods for intervention; and examples of efforts to shape social or behavioral environments or alter basic psychological or neurobiological processes in the service of acquisition and prevention, change, and/or maintenance of behavior. There was also keen interest to discuss innovations in methodology that are needed to advance the science of behavior change, the utility of animal models in research meant to inform understanding of the basic mechanisms underlying human behavior/behavior change, and the development of effective interventions and strategies to maximize the development and maintenance of healthy behaviors in humans.

Keynote speakers were invited to set the stage for each panel by sharing their thoughts on the major issues facing applied/clinical scientists, and commentators were asked to provide an integrative summary and response following panel presentations and discussion. To inform future NIH research initiatives, each of the four breakout session groups was asked to consider

the areas of research most ready for translation, those research areas most likely to be transformative, and ways to facilitate communication between basic and applied scientists in the science of behavior change.

KEY THEMES

In considering the clinical and applied issues in behavior, there was concern that basic research creativity not be constrained by end-application considerations. At the same time, increased focus is needed on the latter stages of the translational continuum; that is, the translation, dissemination, and adoption of research findings. In particular, participants called for more basic research into factors that shape health decision making (e.g., cognitive, social, environmental, and developmental) and the conditions under which knowledge leads to action versus inaction. Indeed, behavioral economic and decision research approaches—such as manipulation of framing and choice architecture as well as the use of financial incentives to promote behavior change—may already be ripe for translation into community-based studies. There was also a call for more policy-relevant research and greater efforts to translate behavioral research findings into policy.

Integrated multilevel approaches to behavior change

The meeting highlighted the importance of projects that link individual- and population-level analyses and the need for multilevel approaches that consider the brain, person, and environment simultaneously and over time. The challenge is how to initiate and maintain health-promoting behaviors that have repercussions at the population level. A profoundly new approach would require an integration of methodology, measurement, and a way of sampling longitudinally at hierarchical levels from the individual to the community to the population (with the appropriate time unit for each level), linking each level to those above and below it.

Behavior "bundles" and the need to target multiple behaviors at once

Behaviors that are clustered or correlated likely have common underlying processes, and considerable support emerged from this meeting for approaches that target multiple behaviors at once, recognizing the difficulty in changing multiple risk behaviors simultaneously. Basic scientists were challenged to offer competing behavioral substitutes and to harness synergies between behaviors to make healthy change easier, incentivize health change without undermining intrinsic motivation, and nudge social networks to spread and sustain healthy lifestyles.

Developmental perspectives on behavior change

Behavior change research should occur within the framework of the human lifespan. For example, epigenetics could be used to identify biomarkers for pivotal biological changes, such as those that occur in response to normal development as well as in response to childhood trauma or stress. Biomarkers for pivotal points of developmental change can be generated by research on neuroimaging, stress endocrinology, genomics, immune/inflammation biomarkers, and psychophysiology.

Environmental context of behavior and behavior change

Participants underscored the importance of studying environmental context of choice and responses to that context, including situational control, stress and brain adaptation, gene-

environment interaction, and application of ecological models, behavioral economics, social network analysis, rational decision making, choice architecture, and framing. There also was considerable interest in capitalizing on the dynamics of social networks for technology-based interventions, particularly among adolescents, and for involving target populations in the development of interventions to ensure their effectiveness.

New methods and measurement

Researchers from a wide range of disciplines, including neurobiology, economics, mathematics, psychology, computer science, neurology, and psychiatry, are using computational approaches to study behavior. There was strong support for developing new methods for collecting, simplifying, analyzing, and disseminating complex, dynamic, and multilevel data and for testing models of such data. Mobile personal sensing devices (e.g., mobile phones) for conducting ecological momentary assessments offer potential as cost-effective delivery platforms for population-scale interventions that can compress data collection intervals from months to hours, minutes, and even seconds; in some situations, real-time functional resonance imaging could be appropriate. Participants also indicated there is a strong need to encourage collaborations between methodologists and clinical scientists and between computational and statistical researchers. In terms of measurement, participants called for unified definitions of contextual variables that allow for more precise, robust, and repeatable measures. Funding for methodologists adept with large datasets as well as standards for such measures will be critical to render the information usable for scientists with widely disparate training.

Better understanding of mechanisms

A fundamental barrier to progress in the science of behavior change has been the lack of understanding about the basic mechanisms of behavior change or the mediators of interventions. There is a significant need for more sophisticated examination of behavioral mechanisms of change as an end in itself. Understanding behavioral mechanisms of change will depend on parsing social identity and social context, which will help expose and remedy health disparities. Some considered research on mechanisms to be an area well suited for interface between basic and applied scientists as well as a forum for transdisciplinary work. Theoretical models of health behavior are influenced by a long history of theory and research in decision making, and implementation of health behavior decisions depends on a number of factors that encompass the cognitive psychological domain but also include ecological factors and neurobiological control resources. An example of one area of research on mechanisms of change is work on executive control over behavior to promote healthier behavioral trajectories. Promising research directions in this area could include approaches for augmenting executive control, enhancing metacognition, and understanding the central role of emotion regulation in many problem behaviors.

Cost effectiveness

Behavioral interventions are often expensive and typically not covered by insurers. More cost-effectiveness data, as well as comparative effectiveness data, are needed, and their implications should be better communicated to policymakers. Powerful tools for promoting healthy behavior change include contingent incentives and technology-based interventions that allow complex interventions to be delivered with fidelity at a low cost and to be readily tailored to special populations.

Dissemination of interventions
As behavior research produces more cross-cutting, multibehavioral interventions, better dissemination strategies will become increasingly important for realizing meaningful public health impact. A major inhibiting factor in dissemination is the lack of an effective and seamless delivery system to effectively communicate scientific research to policymakers, providers, and consumers.

Treatment adherence and relapse
There are a variety of areas in which basic science is needed to help improve research on patient adherence and relapse. These include increasing the validity of self-report, augmenting cognitive function and compensatory strategies, determining the relationship between beliefs/attitudes and behavior, improving teaching and learning strategies, and encouraging self-management. Except for lowering the price of copayments, the effectiveness of most strategies employed to encourage adherence is modest. There is a general sense that information by itself is not effective, which may or may not be true, but it is true that for certain populations (limited English language, low-income, etc.), improved methods for explaining conditions and medications are needed. These populations are more likely to be lower in health literacy and numeracy, which have been linked to lower levels of adherence.

Scientific infrastructure needs
Advances in the science of behavior change require a transdisciplinary and multilevel approach. Institutional silos, conservative review panels, and lack of an incentive structure are some of the oft-cited reasons why transdisciplinary research does not thrive, and participants considered how the NIH might foster this area. Suggestions included development of a common taxonomy and set of measurements, processes, and mechanisms and sustainable structures for cross-disciplinary collaboration, which is not currently rewarded by existing institutions. How researchers are trained generated considerable discussion. There were advocates for transdisciplinary training and for continuing with unidisciplinary training but enhancing it with exposure to transdisciplinary work, a new feature of some NIH training grants. Participants also called for greater interplay between research on the basic mechanisms of change and clinical interventions. Suggestions for accomplishing this included not only exposing students early in their training to other disciplines but also facilitating repeated basic researcher/applied researcher exposures and collaborations over time; for example, with face-to-face meetings, online databases, and/or virtual networks such as the MacArthur Foundation research networks.

In the same vein, participants suggested that the NIH create funding mechanisms for transdisciplinary teams that are less project focused to allow freedom for iterative development of ideas. In essence, some teams of researchers need a longer incubation period because the science grows from the collaboration rather than the inverse. One suggestion was that small grants with participants from multiple disciplines could foster ongoing, robust research collaborations across disciplinary lines.

OVERALL CONCLUSIONS

The science of behavior change has long suffered from fragmentation along scientific and topical boundaries. The mechanisms underlying effective behavior change strategies often remain

obscure, hampering attempts to translate treatments between domains or from controlled trials to populations. Yet because unhealthy behaviors cause so much morbidity and mortality, the status quo cannot prevail. There is, however, renewed hope that the NIH can facilitate progress by supporting research on basic mechanisms of behavior change and by fostering transdisciplinary efforts spanning Institutes, Centers, and levels of analysis.

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MEETING REPORT

INTRODUCTION

In designating the science of behavior change as a National Institutes of Health (NIH) Roadmap activity, with broad participation by 17 Institutes and Centers (ICs), the NIH has sharpened its focus on a topic that is essential for realizing the full potential of biomedical advances. Even modest changes in health behavior can improve health outcomes dramatically and reduce disparities. Although substantial progress has been made and many effective behavioral change interventions have been developed, many challenges remain for researchers and policymakers. There is little doubt that producing behavior change is difficult to accomplish and often requires complex and intensive interventions that are challenging to deliver in the current healthcare system. The Science of Behavior Change Roadmap activity complements the attention to comparative effectiveness research advocated by Congress and supported by the NIH and its sister agencies. Rationalizing the delivery of medical care, while leveraging what is known about the science of behavior change, will translate into cost savings and better outcomes.

The goal of the NIH meeting on the science of behavior change, held June 15 to 16, 2009, in Bethesda, Maryland, was to advance an NIH-wide research agenda in this area, bridging basic science approaches to studying mechanisms and processes of behavior change to applied science on behavior change interventions. The overall meeting format consisted of several components: Three panels designed to address key areas of behavior change science—namely acquisition and prevention of behavior, changing existing behaviors, and maintenance of behavior—followed by a breakout session intended to promote integration and develop ideas for future research directions (see appendices 1 and 2 for the meeting agenda and list of attendees).

The panel divisions were admittedly arbitrary since it is an empirical question whether the same mechanisms are involved in acquisition, change, and maintenance of behavior, and thus, the discussion overlapped panels. The three panels shared the following structure and the common goal of encouraging bidirectional translation between basic science and applied/clinical science:

- A brief “big picture” overview of applied/clinical issues by keynote speakers;
- A series of short basic science presentations addressing processes and mechanisms;
- A discussion between basic and applied scientists on the state of the science and needed advances regarding mechanisms of behavior change;
- A series of short presentations by applied/clinical researchers addressing areas of key scientific challenges;
- A discussion between basic and applied scientists on where process/mechanistic approaches can inform applied and clinical science and applied/clinical problems can inform directions for basic science; and
- Methodological, basic science, and applied/clinical science commentaries integrating and responding to ideas presented by the basic and applied science panelists.

Each panel was asked to address specific questions about basic social, behavioral, psychological, or neurobiological mechanisms and processes; individual differences that may enhance resiliency and the ability to resist adoption of unhealthy behaviors; whether there are particular developmental windows of vulnerability that may disrupt critical periods for intervention; and examples of efforts to shape social or behavioral environments or alter basic psychological or neurobiological process in the service of acquisition and prevention, change, and/or maintenance of behavior. There was also keen interest to discuss innovations in methodology (e.g., experimental design, data collection, measurement, data analysis) that are needed to advance the science of behavior change, the utility of animal models in research to inform understanding of the basic mechanisms underlying human behavior/behavior change, and the development of effective interventions and strategies to maximize the initiation and maintenance of healthy behaviors in humans.

Panelists were given a maximum of 5 minutes to make their key point(s); i.e., focusing on either a seminal finding or a challenge in their work/field. These brief presentations were intended to give the audience a crisp sense of the fundamental research questions and approaches from often disparate fields that can inform the science of behavior change. Panelists also participated actively in the discussions on bidirectional translation between basic and applied clinical science.

Keynote speakers were invited to set the stage for each panel by sharing their thoughts on the big issues facing applied/clinical scientists, and commentators were asked to provide an integrative summary and response following panel presentations and discussion. To inform future NIH research initiatives, each of the four breakout session groups was asked to consider the areas of research most ready for translation, those research areas most likely to be transformative, and ways to facilitate communication between basic and applied scientists in the science of behavior change. In an effort to ensure that a wide range of expert opinions were considered, each breakout session group contained a mix of basic and applied/clinical researchers.

KEY THEMES

The meeting highlighted the importance of vertically integrated projects that link individual- and population-level analyses and promote cross-disciplinary engagement and new collaborations to accelerate the transformation of the health promotion and disease prevention landscape. Health-related behavior change at the individual level is well studied. The greater challenge is how to initiate and maintain health-promoting behaviors at the population level. A radical rethinking of this issue requires a break from linear causality models. Consideration of causal loops implies a cybernetic model in which there is feedback that occurs in nanoseconds (at the level of neural circuitry) and over larger time units as analysis is scaled up, to perhaps macro-patterns over many years. Such a profoundly new approach would require an integration of methodology, measurement, and a new way of sampling longitudinally at hierarchical levels from the individual to the community to the population (with the appropriate time unit for each level), linking to each level above and below. Multilevel approaches that consider the brain, person, and environment simultaneously and over time are needed. The implications for interventions that occur within this more dynamic framework are that they will have to move out of the context of traditional care settings, which exist in silos, and into real-world settings where multiple behaviors occur together in complex environments.

In considering the clinical and applied issues in behavior, there was concern that basic research creativity not be constrained by end-application considerations. However, some argued that increased focus is needed on the latter stages of the translational continuum (translation, dissemination, adoption, and community implementation). For example, while much is known about how to prevent tobacco use, the field lacks knowledge on optimizing the impact of interventions that are known to be effective. Participants further recognized the need to target multiple behaviors at once and the difficulty in changing multiple risk behaviors simultaneously. Basic scientists were challenged to offer competing behavioral substitutes and to find ways to harness synergies between behaviors to make healthy change easier, incentivize health change without undermining intrinsic motivation, and nudge social networks to spread and sustain healthy lifestyles.

Some participants called for more basic research into factors that impact health decision making (e.g., cognitive, social, environmental) and the conditions by which knowledge leads to action versus inaction. Others felt that behavioral economic and decision research approaches such as manipulation of choice architecture and framing are already ripe for translation into community-based studies; for example, some participants envisioned use of these approaches in environments such as school cafeterias. Financial incentives to promote changes in health-related behaviors such as substance abuse, weight reduction, physical activity, and medication compliance are ripe for translation as well. There was also a call for encouragement of policy-relevant research and greater efforts to translate behavioral research findings to the policy level. On a somewhat related note, making use of social marketing to effect broad behavioral change was mentioned as a potential "low-hanging fruit" among other environmental approaches to behavior change.

The remainder of this report fleshes out the themes that emerged from the presentations, commentary, and discussions during panel sessions and in breakout groups.

Behavior "bundles" and the need to target multiple behaviors at once

Acknowledging that risk behaviors often occur in "bundles," basic science studies about risk behaviors should move away from focusing on one behavior at a time. Behaviors that are clustered or correlated likely have common underlying processes, and considerable support emerged from this meeting for approaches that target multiple behaviors at once. Interventions that focus on the most proximal influences (like attitudes, social normative beliefs, self-efficacy, intentions) are usually limited to discrete behaviors, whereas a single, complex intervention targeted to more distal influences may be able to impact multiple behaviors simultaneously.

An example is the Positive Action Program, a multiyear, school-based intervention that addresses multiple risk behaviors in adolescents—substance use, violence, and unsafe sex. The program has successfully reduced all three problem behaviors and increased positive behaviors such as school attendance and academic achievement; notably, the program was most effective among those students at highest risk.[1] The ability to cluster behaviors in a single intervention

[1] Beets MW, Flay BR, Vuchinich S, Snyder FJ, Acock A, Li K-K, Burns K, Washburn IJ, Durlak J. Use of a Social and Character Development Program to Prevent Substance Use, Violent Behaviors, and Sexual Activity Among Elementary-School Students in Hawaii. *Am. J. Public Health*. 2009;99:1438-1445.

may be limited by the complexity of the behavior, and there was some disagreement about the need for massive-dose, intensive interventions as opposed to more opportunistic, just-in-time interventions. More descriptive, explanatory, and predictive research is needed to understand which domains of behavior are more or less susceptible to these contrasting styles of intervention. At the same time, other participants suggested that the NIH target a few high-risk behaviors for attention.

Changing sleep behavior offers a case in point. Sleep was described as a "hub science"; that is, improving sleep can improve health-related quality of life, cognition, and emotion regulation and decrease substance abuse.[2] Progress in sleep science can be made by identifying mediators and moderators of treatment outcome, identifying temporal strategies for the optimal use of multicomponent treatments, pursuing new directions in treatment/patient interaction (e.g., epigenetics, neurobiological effects of treatment), and strengthening treatment by using technology to bring therapy into patients' homes to increase objective data on sleep behaviors and intervene in the patients' contexts.

Developmental perspectives on behavior change

Behavior change research should occur within the framework of the human lifespan. For example, epigenetics could be used to identify biomarkers for pivotal biological changes, such as those that occur in response to normal development as well as response to childhood trauma or stress. It may be possible to intervene at these identified time points to prevent deleterious epigenetic changes from being passed on to offspring. Biomarkers for pivotal points of change also can be generated by research into neuroimaging, stress endocrinology, genomics, immune/inflammation biomarkers, and psychophysiology.

Facets of personality, like conscientiousness, go through changes that do not stop when the prefrontal lobe is fully functional. There are natural environmental changes (education, workforce transitions, and family role occupancies) that influence personality development, and there is individual variability in how people change in response to these life events and how they develop and foster self-regulation. Given these dramatic shifts, it may be possible to foster personality development in ways that result in healthier outcomes.

A developmental approach to behavior change does not necessarily assume that earlier intervention is better but rather that there may be critical developmental stages at which targeted interventions would be most effective. Adolescence may be one such stage. Given adolescents' focus on sensation seeking, one area of interest is understanding adolescent risk taking, particularly in social contexts. Adolescence is a time when the influence of peers becomes more profound as demonstrated in experimental settings where adolescents have been found more likely to engage in risky behaviors (e.g., reckless driving) if a peer is present. A recent review of this literature dispels several pervasive myths, including the idea that teens take risks because

Flay BR, Allred CG, Ordway N. Effects of the Positive Action program on achievement and discipline: Two matched-control comparisons. *Prevention Science*. 2001; 2(2): 71-89.

[2] Bootzin RR. Why is sleep important? The short- and long-term consequences of sleep disturbance. Invited address, Association for Psychological Science Convention, Chicago, IL. May 2008.

they think that they are immortal, and provides evidence that decision processes change as adolescents mature to become healthy adults.[3]

A primary source of problems in adolescence is control of behavior and emotion, and behavioral patterns are set during adolescence that will affect individuals over the lifespan. Adolescence is also a period that sees increasing rates of accidents, suicide, homicide, depression, alcohol and substance use, violence, reckless behaviors, eating disorders, and health problems related to risky sexual behaviors. Emotional and motivational changes occur at puberty as does the development of self-regulatory processes. Accordingly, adolescence, or the transition to adolescence, may constitute a prime developmental stage for further basic science investigation and targeted interventions. Conducting experiments in social groups to understand how the prospect of impressing one's peers nudges behavior could be very powerful and provide an opportunity to work across levels, from the social to the neural levels. Other compelling questions about adolescence are how hormones may influence brain development and, in turn, impact behavior.

However, adolescence may be late in terms of developing emotional self-regulation as individual differences in the ability to self-regulate have been identified as early as 3 or 4 years of age, and this factor seems to have predictive power for life outcomes (although there seems to be development from adolescence to adulthood in impulsivity and other aspects of self-regulation and emotional intelligence). Of course, targeted populations have to have biological systems that are receptive to the intervention, and there may be multiple points in the lifespan in which individuals are "ripe" for intervention; interventions would need to be tailored according to the relevant etiologic changes throughout the stages of life.

How children cope, particularly in terms of problem-solving and social skills, is a primary driver in metabolic and quality-of-life outcomes. One particular intervention—coping skills training (CST)—was designed to increase the individual's sense of mastery and form more positive patterns of social behavior. The skills taught are not unique to chronic disease; they include social problem-solving, communication, basic social skills, cognitive behavior modification, and conflict resolution. When first implemented in the mid-1990s, CST combined with intensified treatment management had measurable positive effect compared to the control group in intensified treatment management only.[4] These results have spawned a study of Internet delivery of CST in children with type 1 diabetes as well as a randomized controlled trial of CST to prevent type 2 diabetes using a community-based participatory research model among high-risk, minority seventh graders.

One issue in research with children and adolescents is understanding their social ecological context (i.e., their families) from a developmental perspective. Translating effective interventions to target young people can benefit from a community-based participatory model; more long-term (e.g., over a year), multilevel studies that look at sustaining behavior changes; and creative use of technology to engage young people, particularly interactive formats that mimic a group intervention.

[3] Reyna VF, Farley F. Risk and rationality in adolescent decision-making: Implications for theory, practice, and public policy. *Psychological Science in the Public Interest*, 2006; 7(1):1-44.
[4] Grey M, Boland EA, Davidson M, Li J, Tamborlane WV. Coping skills training for youth with diabetes mellitus has long-lasting effects on metabolic control and quality of life. *J. Pediatr*. 2000;137(1):107-13.

Behavioral economics, rational decision making, choice architecture, and framing

Evidence suggests that three problem behaviors—smoking, poor diet, and physical activity—persist not because people lack education or are irrational. In fact, in a study comparing depressed and schizophrenic smokers with normal smokers, the patients with mental illness appeared to be the more rational actors based on their espoused beliefs about the pros and cons of smoking.[5] Fuzzy-trace theory posits that rational behavior may actually not produce the most protective health behaviors.[6] According to this theory, people perceive a situation using two kinds of mental representations: Verbatim representations, which are literal, precise, and quantitative, and gist representations, which are qualitative interpretation of a situation based on factors such as emotion, education, culture, and experience. People actually prefer to rely on gist-based intuition, which supports the notion that people are not rational actors. This nonrational approach seems to be, in fact, more developmentally advanced, as children shift from reliance on verbatim representations in decision making toward more gist-based decision making as they mature. Thus, somewhat counterintuitively, gist-based thinking appears to be health protective; for example, a purely rational calculus for HIV promotes risk taking. A radical proposal is that adolescents take risks precisely because they are *too* rational.[7]

Behavioral economics shares some core principles with classical economics; for instance, that incentives matter and that people primarily respond to prices. However, there are some major differences, foremost of which are the notions that people have limited processing ability and willpower, that preferences are often constructed, and that social mechanisms can be far more powerful than greed. Behavioral economists recognize that immediate costs and benefits have disproportionate weight. Consequently, people tend to avoid and/or delay investment behaviors, such as human capital formation (education), exercise, diet, sexual abstinence, smoking abstinence, medical adherence, and saving. In short, every investment activity is vulnerable to this present bias. In the framework of behavioral economics, the role of the environment in determining choice is profound.

Choice architecture essentially "nudges" people to make the choice that they want to make or the choices they should make rather than requiring them to mobilize the motivation to change. Several assumptions are fundamental to choice architecture: A wide variety of design decisions influences what people choose, everyone presenting decisions is a choice architect, and there is no neutral environment. Further, successfully using choice architecture depends on a deep, descriptive understanding of decision making that draws from neuroeconomics and psychology. From a cost/benefit analysis, choice architecture may prove to outstrip other traditional behavior change approaches; e.g., incentives and persuasion.

Three savings interventions, based in the behavioral economics model, have successfully changed 401(k) enrollment behavior: Automatic enrollment, active decision enrollment with a

[5] Spring B, Pingitore R, McChargue DE. Reward value of cigarette smoking for comparably heavy smoking schizophrenic, depressed and nonpatient smokers. *American Journal of Psychiatry*. 2003;160(2):316-322.
[6] Reyna VF. A theory of medical decision making and health: Fuzzy-trace theory. *Medical Decision Making*. 2008;28:850-865.
[7] Reyna and Farley, 2006.

deadline, and simplified enrollment.[8] These ideas can be extended to the health domain, and one group is beginning a pilot intervention to use active decision making for people to enroll in home delivery of their medications. Other potential interventions could include setting the choice most beneficial to the individual as the default option. Examples might include default appointments (e.g., colonoscopy); default nutrition (e.g., workplace/school cafeterias, vending); default immunization (e.g., flu vaccination); and default medical procedures, such as for the use of stents versus drugs in diabetics with cardiovascular disease. Finally, the neural mechanisms underlying these behaviors seem to be seated in two systems that are sometimes in disagreement: The analytic cortex, the seat of self-regulation, versus the mesolimbic dopamine reward system, which encourages the agent to engage in immediate gratification.[9]

Organ donation offers another case study: 100,000 people in the United States are on the waiting list for organs, and proposed solutions to this crisis include economic incentives (e.g., market-based pricing, payment for burial expenses, tax deductions) and persuading people that organ donation is "a good thing." A third solution—changing the defaults—is predicated on the notion that while most people have positive feelings toward organ donation in the abstract, they dislike thinking about the decision to donate their own organs. One study concluded that defaults improve organ donation rates, on the order of 16 to 50 percent.[10]

Changing the defaults is one choice architecture device; others include choice set design (inclusion, ordering, formatting), social modeling, commitment plans, and reminder systems. The salience of the immediate environment and the possibilities if it were to be altered are exemplified in eating behavior. Immediate environmental variables, including packaging size, perceived variety, the size and shape of food containers, and food stockpiles, can lead people to unknowingly overeat. These environmental cues influence consumption volume in two ways: They are mediated by consumption norms and can bias consumption norms. While these factors likely influence all people to some extent, it may be more effective to target interventions to one segment of the population: The predisposed. Unlike the vigilant or the resigned/resistant, predisposed individuals would like to change if change is easy enough. These individuals seem to be the most responsive when the environment around them is changed. Thus, with this group it would be possible to achieve the biggest effect for the smallest cost. Strategies based on the notion that "it's easier to change your environment than to change your mind" are found at smarterlunchrooms.org. Using such a strategy, packaged snacks located at the "bottleneck" areas of lunchrooms, where they are purchased in great quantity, can be replaced with fruits and vegetables. Similarly, making healthy eating "cool," for example, could be an effective social driver of environmental change.

There was also interest among participants in blending social networking with behavioral economics; i.e., social behavioral economics. An intervention that begins with economic-based incentives to power brokers could be sustained by building social networks that reinforce actions. A related line of research to be explored is how to incentivize businesses that are already

[8] See, for example, Carroll GD, Choi J, Laibson D, Madrian BC, Metrick A. Optimal Defaults and Active Decisions. (Forthcoming, *Quarterly Journal of Economics*)
[9] Hare TA, Camerer CF, Rangel A. Self-control in decision-making involves modulation of the vmPFC valuation system. *Science*. 2009;324(5927):646-8.
[10] Johnson EJ, Goldstein D. Medicine. Do defaults save lives? *Science*. 2003;302(5649):1338-9.

involved in motivating change to motivate customers toward healthy behaviors. The partnership of the U.S. Department of Agriculture and mypyramid.gov established incentives for businesses in just this way.

Environmental context of behavior and behavior change and implications for treatment

Understanding behaviors in the context of the immediate, real-world environment is necessary to understand how to change those behaviors. Participants raised a number of observations that underscored the importance of studying environmental context and response to that context:

- Situational control is an important variable to understand given that trait variation has subtle consequences that are difficult to measure. The mismatch between humans' evolved physiology and contemporary environments requires more self-regulation to avoid self-defeating behaviors, creating a conflagration of conditions to produce problems such as obesity.
- Key environmental factors that crystallized in the 1980s clearly have driven the obesity epidemic, suggesting that large-scale environmental and policy changes are needed to effect change at the population level.
- There is rampant inequality in the United States with regard to the need for self-regulation in one's environment, particularly along socioeconomic lines. As the current environment selectively disadvantages some over others, changing the ecological context would, in a way, "level the playing field."
- Developed countries that rank higher than the United States in terms of average life expectancy have more comprehensive and inclusive healthcare systems and less dramatic income inequality.

Stress and brain adaptation

Stress is a known environmental factor in psychopathology.[11] While the impacts of environmental stressors on behavior are profound, there is also evidence from a rodent model and humans that, in the case of behavior, it is reversible.[12] These findings indicate the adaptability of stress-related brain systems and have implications for stress reduction to improve cognitive performance in stressed populations, such as cancer patients.

Gene-environment interactions

Understanding how behavioral phenotypes respond to environmental demands also has important implications for treatment. The behavior research community needs to move away from descriptive characterizations of groups and into levels of analysis that take into account causal mechanisms and alterations in the environmental context that result in adaptive behavior. Accordingly, genetic research has evolved from a model in which genes were thought of as direct causes of disorders to one in which genes are conceptualized as moderators of how individuals respond to environmental factors. Gene-environment interaction findings are based

[11] Caspi A, Sugden K, Moffitt TE, Taylor A, Craig IW, Harrington H, McClay J, Mill J, Martin J, Braithwaite A, Poulton R. Influence of life stress on depression: moderation by a polymorphism in the 5-HTT gene. *Science*. 2003;301(5631):386-9.

[12] Liston C, McEwen BS, Casey BJ. Psychosocial stress reversibly disrupts prefrontal processing and attentional control. *Proc. Natl. Acad. Sci. U. S. A.* 2009;106(3):912-7.

on epidemiology, but the field is progressing to include validation at the neuroscientific level, which increasingly emphasizes the strengths of the controlled experimental method. In mental illness investigations incorporating neuroscientific research, the contribution of the gene-environment interaction to a disorder can be understood at the level of neural substrate reactivity.

Application of ecological models

Favorable environments can reinforce and improve the effects of individual interventions, affecting large populations with relatively permanent effects. The ecological model of health behavior underscores the importance of environmental influences for reinforcing or undermining individual actions. Two presenters applied the ecological model for conceptualizing behaviors associated with physical activity and oral health, respectively.

Despite the accepted benefits of regular physical activity such as walking, increases in physical activity levels will continue to prove elusive if the environment is such that walking is unnecessary or unsafe. The Neighborhood Quality of Life Study contrasted neighborhoods by income and "walkability" ("high-walkable" neighborhoods are mixed use, connected, and dense; walking for transportation in "low-walkable" neighborhoods is nearly impossible) and found a significant walkability effect operating for both high- and low-income neighborhoods (with a weekly difference of about 30 to 45 minutes of objectively measured physical activity).[13] The environment must make it possible or convenient for people to be active and facilitate their ability to take advantage of these opportunities. Public health researchers need to collaborate with urban planners, transportation engineers, parks and recreation personnel, landscape architects, educators, and policymakers, who control the spaces where people are active, which are usually places over which public health has no control; e.g., neighborhoods, city parks, workplaces.

While traditionally work on oral health has focused on the individual, an ecological model reveals that there are important overlapping contextual (child, family, and community) influences. Dental caries is an infectious disease and disproportionately affects children from disadvantaged and minority populations.[14] A child's behavior is influenced by the parents' knowledge, culture, attitudes, and behavior. For example, parents' oral health self-efficacy and parenting skills influence the child's diet, bottle use, oral hygiene, dental utilization, and bacterial transmission from parent to child. Because many parents do not know the etiology of dental caries or that baby teeth are important, education is important but not sufficient to change and maintain behavior. Provider behavior is also important; for example, accepting Medicaid and referring children to the dentist beginning from age 1. The next level of influence is the interaction between healthcare system and community intervention efforts to provide public interventions to improve oral health and awareness; e.g., school-based prevention programs. Policymakers also can make the environment more conducive to oral health by providing, for example, water fluoridation as a very low cost, effective public health intervention that does not require patient compliance; increasing Medicaid dental benefits for children and their parents;

[13] Sallis JF, Saelens BE, Frank LD, Conway TL, Slymen DJ, Cain KL, Chapman JE, Kerr J. Neighborhood built environment and income: examining multiple health outcomes. *Soc. Sci. Med*. 2009;68(7):1285-93.

[14] The recent increase in dental caries may in part be due to increased use of bottled water, which is usually not fluoridated.

changing the scope of practice for healthcare providers to include oral health education and fluoride varnish; and including dental care in healthcare reform.

Social networks and social engagement

Social network modeling can be useful as a way to understand acquisition of behavior and behavior change as well as for designing interventions to accelerate behavior change. Social network models grew out of the knowledge that people are influenced by those around them; e.g., smokers are more likely to have smokers in their networks, and obese adolescents are more likely to have obese friends. This strong association between the behaviors of an individual and those of others in his or her social network can be further weighted by the strengths of association between two individuals; for example, in the HIV community, people are more likely to share syringes with people with whom they have very close relationships. Modeling tie distance (e.g., whether the relationship is in one's immediate social network or further afield) and strength (e.g., best friend versus acquaintance) further clarifies how relationships affect behavior. Understanding the dynamics of social networks—who communicates with whom, who influences whom, etc.—is important in understanding how people change and make decisions.

A fundamental issue that remains unresolved in this field is the relationship between social network exposures and social network thresholds.[15] Someone in a social network has to have a low network threshold; that is, they have to "pioneer" a behavior for the group. Given that people have varying thresholds, the way network exposure is weighted can be changed. When modeling networks it is not possible to know if the threshold has been identified or if the network exposure weighting is misspecified. Resolving this problem is fundamental to understanding social networks, and being able to correctly identify the low-threshold individuals in a network who are socially influential and to change their behavior could, in turn, influence the behavior of the network through natural social processes. In this case, the messenger may be more important than the message.

On a larger scale, existing virtual social networks (Facebook, Twitter) can both serve as interesting subjects of study and a platform to transform behavior. There was considerable interest in capitalizing on the dynamics of social networks for technology-based interventions, particularly among adolescents. For example, one could imagine a therapeutically designed virtual community to positively influence the behaviors of participants as well as give them the opportunity to learn vicariously about another way of existence. A social network approach in technology could exploit the idea that people are more likely to engage in healthy behaviors (e.g., exercise) in a group setting. Another possibility is medication adherence, which certainly constitutes a problem in isolation but might be amenable to creation of a virtual support system to enhance adherence. While virtual networks lack the spontaneity of real life, their existence is already changing the way people behave. Thus, the rise of natural networks such as Facebook is a phenomenon worth studying at the basic science level. At the applied level, virtual network communities could enhance knowledge-based interventions or even be the primary intervention.

There was also a strong push for involving the target population in the development of the technological intervention to ensure that it is effective. Design must take into account unique environmental factors among that population; for instance, among economically disadvantaged

[15] Valente TW. Social network thresholds in the diffusion of innovations. *Social Networks*, 1996;18:69-89.

individuals, the high-speed Internet access required for some highly interactive interventions is nonexistent or unreliable. Interventions for these populations must, therefore, be developed in such a way that loss of Internet access does not cripple the entire intervention.

Technology also could be used to advance understanding of the basic mechanisms involved in choices made in a social context. Based on preliminary social interactive experiments using high-throughput imaging scanners, researchers surmised that when an individual values the action of another person in the group and follows their decision, more basic brain regions (such as the ventral striatum) come online.[16] Monitoring these regions in real time can permit likely guesses about what individuals will do next. Though technologies such as this do not scale up, they might offer clues about this facet of decision making.

New methods and measurement

There was strong support for development of new methods for collecting, simplifying, analyzing, and disseminating complex, dynamic, and multilevel data, such as that generated by real-time functional magnetic resonance imaging (fMRI) and genomic analyses. One way of achieving this could be by soliciting applications that explicitly link methodology with clinical science. Some participants suggested that new ways of conceptualizing existing datasets might be achieved by collaborations between computational and statistical researchers. In addition to making data accessible for mining and sharing, it also was suggested that researchers take an engineering-like approach to data mining that is hypothesis driven. Finally, there were requests for model development, particularly dynamic as opposed to statistical models. In terms of measurement, participants asked for unified definitions of contextual variables that allow for more precise, robust, and repeatable measures. The Internet has already transformed researchers' ability to collect information, and the next wave of technological revolution is the use of mobile personal devices (e.g., mobile phones) for conducting ecological momentary assessments and as cost-effective delivery platforms for population-scale interventions.

Timeframes, context, and data collection methods

Understanding behavior change relies on the theoretical, statistical, and methodological models used. Although there is a general tendency for theories to explain behavior at the level of individual differences or traits, background variables, which change over weeks or months, are more variable and potentially more potent. Precipitating variables, which change over hours, minutes, or seconds, are more difficult to measure than individual traits. As a result, there is often a disconnect between theories and methods in that theories implicate exposures or cues with high levels of variability over time but measures of these variables are often taken only every few months. An example is using ecological momentary assessment to capture rapidly changing processes; e.g., random time samples taken on a mobile phone. An example of a variable that would benefit from more frequent measurement is stress. Stress is a slowly building, cumulative process, but the measurements of stress are often spaced too far apart to capture this cumulative process. Further, data show no relationship between stress experienced yesterday and a lapse in positive behavior change (e.g., smoking a cigarette) today; however, negative affect can be building in the hours before the lapse.[17] In order to understand this and

[16] Work of Read Montague and colleagues.
[17] Shiffman S. Dynamic influences on smoking relapse process. *J. Pers*. 2005;73(6):1715-48.

similar processes, the time scale of measurements needs to be better aligned with the time scale of the phenomena as well as theoretical and more dynamic models. Timeframes need to be compressed from months to hours, minutes, and even seconds.

New computational approaches

Researchers from a wide range of disciplines, including neurobiology, economics, mathematics, psychology, computer science, neurology, and psychiatry, are using computational approaches to study behavior. Employing fairness games, which are staged games for which there are normative solutions, researchers are seeking to expose the computations involved in person-to-person interactions. The games require participants to compute or retrieve norms for the behavior, sense deviations in norms, and select appropriate actions. The results in work on mental illness and behavior have generated potential endophenotypes for areas that have as yet no agnostic quantitative phenotypes; e.g., Autism spectrum disorders, borderline personality disorder, addiction. Similar approaches may be useful for exposing social signals in ways that can be modeled and revealing brain signals that can be used to look for genes underlying disorders.

Promise of technology for measuring the "environome"

The promises of technology in relation to behavior change are many: It permits the gathering of data on participants away from the constraints of a laboratory and in the context of real life, it has potential to be used in engineering environmental change, it can bring interventions out of the clinic and into the real-world context, it can be a platform for interventions that are less obtrusive and more passive, it is conducive to noninvasive monitoring that can reveal when and in what context people are having greater or less success in changing their behaviors, and it potentially could marry interventions with electronic medical records. Mobile phone technology also offers the possibility of studying the temporal instability of intentions, which is somewhat attributable to the fact that attention changes over time, partly due to the impact of the environment. In order to realize these promises, there is a need for technological interventions that are empirically and theoretically based and designed specifically for the target populations.

Mobile phones as intervention devices have a number of advantages, including that they are carried nearly everywhere and are the objects of massive industry investment for improvement. They also have increasingly sensitive capabilities (for example, using pattern recognition to identify location, points of interest, people nearby, motion/steps/physical activity, type of transportation, and social connectedness) and allow keyword spotting and audio sampling. Further, mobile phones have multiple feedback mechanisms and can be helpful for mediating messages through a close friend or family member.

Methods are needed to determine the optimal way to deliver interventions through personal devices such as mobile phones and PDAs. Multidisciplinary creative teams should be encouraged to collaboratively and iteratively design interventions. Open platforms that allow health researchers across domains to utilize this technology would be useful, as well as pairing academic scientists with product design companies. Marketing experts also are potentially valuable resources in designing interventions that are seamlessly integrated into the context of daily life. Characteristics of effective interventions include simple message(s), delivered at the right time and right place, in a nondisruptive fashion in repeated and consistent ways. With their computational sensing capabilities for time and location as well as their fidelity of

implementation, mobile phones are ideal delivery devices, with the caveat that attention is required at the level of interface design to ensure that the message is appropriately tailored.

In addition to framing individual behavior within the immediate environment, the data gathered about that environment could form the basis of an "environome" in which environmental variables are understood in terms of their level of effect; e.g., external, epigenetic. Of course, such an approach would generate an enormous amount of data, which would be a challenge to utilize effectively. Funding for methodologists adept with large datasets as well as standards measurements will be critical to render the information usable.

Application of real-time functional brain imaging

It now takes seconds rather than days or weeks to process massive amounts of data generated by fMRI so that a subject in a scanner can, for example, observe his or her own patterns of brain activation and, with learning, select a brain region to control. Applications of this technology include a psychotherapist interacting with a patient in the scanner and observing brain activation in response to treatment to have greater awareness of its effects; in the future, it may be possible to use this approach to understand the mechanisms that allow cognitive and behavioral change to occur. Ongoing research suggests that it might be possible to transfer even complex patterns of behavior from one person to another through mimicry training.[18] If executive functioning can be measured with patterns of activation, it might be possible to construct experiments using fMRI to detect when subjects are undergoing particular cognitive processes and train them to do so better or differently. The use of fMRI may also inform understanding about how a social network influences individual functioning.

e-Health and behavior change

Behavior cannot be comprehensively understood at any one level of analysis, and behavior change is built on the foundation of knowledge, barrier reduction, and behavioral supports. The possibility of developing a discipline-independent research framework to guide investigation is conditional on identifying the fundamental unit of behavior so that anybody can use that metric across levels of analysis. Greater precision in the behavioral and social realm is required to predict how outcomes will change in response to a change in the environment. e-Health offers promise to revolutionize the behavioral and social sciences, as it has already revolutionized molecular biology, to allow for mass customization; development of behavioral libraries and causal profiles; and, eventually, "populomics" (systems integrative science). Technology-enabled behavioral intervention/treatments are many, and there are e-health investigators already researching, for example, whether virtual social networks have similar effects as an in-person Alcoholics Anonymous meeting.

As e-health is a rapidly changing field, participants welcomed having a mechanism by which they can be made aware of what is becoming available that may be relevant to their work. There was a call for NIH support for open-source platform work as well as for allowing development through private enterprise.

[18] deCharms RC. Applications of real-time fMRI. *Nat. Rev. Neurosci*. 2008;9(9):720-9.

Better understanding of mechanisms

A fundamental barrier to progress in the science of behavior change has been the lack of understanding about the basic mechanisms of behavior or the mediators of interventions. Even when people know what needs to be done, they sometimes lack the ability or desire to actually do it. There is limited understanding of the mechanisms of behavior initiation, change, and maintenance; whether mechanisms governing these aspects of behavior change are even the same; and individual variation in capacities (e.g., self-regulation) with regard to these mechanisms.

There is a significant need for more sophisticated examination of behavioral mechanisms of change as an end in itself. For example, in a meta-analysis of motivational interviewing interventions for alcohol addiction, only 19 of the studies even addressed a mechanism of change or potential mediator, only 2 conducted complete mediation analysis, and only 1 showed evidence for partial mediation (and only for a subset of clients).[19] There are several ways to ameliorate this lack of mechanistic information; namely, greater specification of theory, operationalization of constructs, and use of sophisticated analytic techniques and computer software programs to test more complex models. Effective treatments, particularly over the short term, have been established for problem behaviors, but the essential ingredients of treatments or their mechanisms of change remain to be identified.

Behavioral mechanisms of change will depend on social identity and social context, which will help expose and remedy health disparities. For example, research needs to address the relative importance of social norms compared with internally calculated decisions across subculture, class, ethnicity, age, and gender groups. The perception of social stigma associated with various disorders also varies with social identity (e.g., obesity is more accepted in some groups than others), and perceived control over health likewise varies. In short, the social context shapes the relevant behavioral mechanisms.

Better understanding of mechanisms holds promise for tailoring interventions to the biophysiologic capacity of individuals and individual differences in, for example, resistance and resilience. There may even be a mechanism driving health disparities that, once uncovered, could lead to understanding of why such disparities exist. However, the tension between the need for community-level and broad-scale approaches versus those focused on the individual persists. Some participants considered research on mechanisms to be an area well suited as an interface for basic and applied scientists as well as a forum for transdisciplinary work.

In terms of population health, the spread of obesity in social networks represents a key finding,[20] but the induction process by which obesity is "transmitted" is not well understood. Thus, this finding has yet to make an impact in terms of interventions, and effort should be devoted to understanding the mechanisms of transaction in this framework. An alternative to work on independent risk factors might be "master disease assembly algorithms"[21] to understand disease

[19] Apodaca TR, Longabaugh R. Mechanisms of change in motivational interviewing: a review and preliminary evaluation of the evidence. *Addiction*. 2009;104(5):705-15.
[20] Christakis NA, Fowler JH. The spread of obesity in a large social network over 32 years. *N. Engl. J. Med.* 2007;357(4):370-9.
[21] Work of Thomas Glass and colleagues.

clusters and underlying mechanisms. Perhaps greater attention should be focused on changing the environment rather than changing individual behaviors. Promising research avenues may involve studying networks as complex adaptive systems, using sensors to measure behavior/actions and network connections, and harnessing networks for interventions.

Decision making and executive function

Theoretical models of health behavior are influenced by a long history of theory and research in decision making although recent models increasingly depart from utility formulations and emphasize psychological factors, such as affect and memory. However, much less is known about decision implementation. Decision implementation may be especially important for understanding maintenance of health behavior change over time. Implementation of health behavior decisions could depend on a number of factors that encompass the social-cognitive domain but also include ecological factors and neurobiological control resources. Executive function is one example of such a control resource. Studies have consistently found that higher cognitive ability is associated with greater longevity, and more specific executive control processes may account for most of this association.[22] Stronger executive control abilities have also been associated with more consistent performance of health-protective behaviors and better calibration of behavior to intentions. According to construal level theory, level of representation (e.g., higher order gist) may facilitate self-control and, hence, healthier preferences. The Western living environment may actually make healthy behaviors more difficult, thereby increasing the requirement for effortful control to maintain health. Promising research directions related to executive control might include approaches for augmenting executive control in ways that are conducive to healthy behavioral trajectories; e.g., through direct manipulation of the abilities with the use of pharmacotherapies and cognitive retraining or indirectly by training cognitive compensatory strategies. Ecological approaches that reduce demand on control resources are also promising; i.e., making healthy choices easy choices to enact.

Learning, memory, and metacognition

Metacognition is awareness of one's own cognition. Mindfulness is often described as a metacognitive state of awareness. Its connection to rehabilitation is that awareness of deficit is a major factor in whether people will improve. Metacognition is thought of as important in cognitive psychology because it confers control; that is, we need to know what we do not know in order to ameliorate the situation. There is now a well-established connection between what people know and what they do. Research on the delayed judgment of learning paradigm in elementary schoolchildren has established that their metacognition is surprisingly accurate, but they have an implementation deficit, rendering them unable to benefit in their actions from their (very accurate) metacognition.[23] Adults have been shown to have limited metacognitive insight into their abilities, including their ability to resist unhealthy temptations.[24] The kinds of processes involved in metacognition are not well understood, and the signal needed to convert

[22] Hall, P.A., Dubin, J., Crossley, M., Holmqvist, M. & D'Arcy, C. (2009). Does executive function explain the IQ-mortality association? Evidence from the Canadian Study on Health and Aging. *Psychosomatic Medicine, 71*, 196-204.

[23] Work of Janet Metcalfe and colleagues.

[24] Dunning D, Health C, Suls JM. Flawed self-assessment: Implications for health, education, and the workplace. *Psychological Science in the Public Interest*, 2004;5:69-106.

Sayette MA, Loewenstein G, Griffin KM, Black J. Exploring the Cold-to-Hot Empathy Gap in Smokers. *Psychological Science*, 2008;19: 926-932.

knowledge into control is unknown. Greater specificity surrounding these signals (such as executive control and "hot" versus "cool" modulation) would allow their use in appropriate situations.

Emotion dysregulation

One possible framework for understanding behavior and interventions is to consider the individual moving toward a homeostatic interoceptive affective state. If so, then it may be promising to look at other areas of the brain, like the insular cortex, where there is interoception or sensitivity to stimuli originating inside the body. As there is wide variability in interoceptive capacity and conscious access to interoceptive cues, this could be a potential place to focus attempts to both understand behavior and intervene in it.

Emotion dysregulation plays a central role in many problem behaviors, and there is already translational work linking mechanisms of emotional generation and regulation to depression, anxiety disorders, and addiction. In the emotion regulation model, emotion generation occurs in an iterative cycle of a situation or stimuli, attending to that stimuli, appraisal of its significance and its relevance to one's goals/wants/needs, and emotional response to that stimuli. People employ different strategies in response to stimuli as a means of regulating their response; e.g., they may avoid or modify the situation, attend to different aspects of it, or cognitively change the way they appraise its significance. For example, in fMRI studies of subjects viewing a potentially arousing photo, amygdala activity changed based on the subject's interpretation of that stimuli; i.e., whether they thought about the photo in a more or less negative way.[25] Work in this model can be useful to diagnose dysfunctional mechanisms, devise interventions that target them, and track treatment-related changes in the integrity/function of those mechanisms.

Interventions targeting underlying mechanisms relevant to multiple behaviors

There is some tension in the behavior change research community between interventions focused on discrete behaviors versus those that target underlying mechanisms that have relevance to multiple behaviors. On the one hand, a handful of behaviors account for the most morbidity and mortality; most notably, smoking, eating, drinking, inactivity, and poor sleep. Consider that tobacco use is estimated (at current usage rates) to cause 1 billion deaths by 2050, and a reduction of 10 percent in cigarette consumption today would prevent an estimated 10 million cancer deaths by 2030.[26] On the other hand, increasing the numbers of interventions targeted to specific behaviors overwhelms already-burdened primary care providers, some of whom have asked for a generic behavior change or prevention intervention into which the provider can "plug in" the problem behavior. In such "prefabricated interventions" based on the common principles and processes found in effective interventions, content becomes secondary to the intervention process.

Tailoring interventions

To be most effective, interventions should be constructed based on the social, environmental, and cultural context of the target population, recognizing that every intervention has its foundation in

[25] Ochsner KN, Ray RD, Cooper JC, Robertson ER, Chopra S, Gabrieli JD, Gross JJ. For better or for worse: neural systems supporting the cognitive down- and up-regulation of negative emotion. *Neuroimage*. 2004;23(2):483-99.
[26] World Bank. *Curbing the epidemic: Governments and the economics of tobacco control.* World Bank Publications, 1999. p80.

how it frames the issue. Tailoring interventions to reach high-risk populations (such as people with addictions or people most susceptible to addiction) in relatively unconstrained environments can be facilitated by borrowing concepts from behavioral economics and other areas of basic science fields, such as neuroscience, genetics, or behavioral and/or social psychology. For example, a robust finding using behavioral economic measures is that people with addictive behavior patterns discount the future more steeply than those who do not. Thus, an alternative to the traditional intervention model of lengthening intervals over which behavior is organized to promote beneficial change is found in the concept of asymmetric paternalism.[27] Under this framework, the interventionist accepts that there is bias in choice and frames the choice context to help those who have the most biased choices in decision making habits. For example, treatment on demand rather than setting a high threshold for entrance to treatment programs is based on the notion that motivation is dynamic, and thus, the care model should be similarly opportunistic.

Research on nicotine dependence illustrates the promise of tailored interventions. With respect to nicotine dependence, one study found evidence for two distinct groups of adolescents that differed in nicotine metabolism: Trajectory 1 (mostly slower metabolizers) had early onset of use but slower rate of nicotine dependence compared to trajectory 2 (comprising mostly faster metabolizers) with a more rapid acceleration in the rate of dependence.[28] This preliminary finding suggests that early onset may be important for interventions, but it may also be the case that the phenotype that represents more rapid emergence of nicotine dependence may define a more recalcitrant smoking problem in adulthood. Informing intervention timing with information about nicotine metabolism may be critical. In treatment, these findings revealed the following: Slow metabolizers benefit from the nicotine patch while fast metabolizers fare better with bupropion or non-nicotine medication, which suggests that tailoring the pharmacotherapy to metabolic activity could improve outcomes.[29] Understanding the mechanisms underlying the etiology of nicotine dependence may promote more effective smoking prevention interventions and response to treatment.

Despite the literature supporting the notion that people who engage in aerobic activity have increased positive affect, many people do not exercise. In a translational model of exercise behavior,[30] underlying genetic factors that influence how people respond to a bout of exercise comprise one facet of this multidimensional model. There appears to be somewhat more variability in the way people respond to exercise, both physiologically and psychologically. This variability can be attributed, in part, to underlying genetic factors; for example, the BDNF single-nucleotide polymorphism. These differential responses to exercise translate into psychosocial variables that impact behavior (e.g., motivation, self-efficacy) and, eventually, the behavior itself. Interventions tailored to differences in these interacting variables across levels

[27] Loewenstein G, Brennan T, Volpp K. Asymmetric Paternalism to Improve Health Behaviors. *JAMA*. 2007; 298(20):2415-2417.
[28] Audrain-McGovern J, Al Koudsi N, Rodriguez D, Wileyto EP, Shields PG, Tyndale RF. The role of CYP2A6 in the emergence of nicotine dependence in adolescents. *Pediatrics*. 2007;119(1):e264-74.
[29] Schnoll RA, Patterson F, Wileyto EP, Tyndale RF, Benowitz N, Lerman C. Nicotine metabolic rate predicts successful smoking cessation with transdermal nicotine: A validation study. *Pharmacology, Biochemistry, and Behavior*. 2009;92(1):6-11.
[30] Bryan A, Hutchison KE, Seals DS, Allen DL. A transdisciplinary model integrating genetic, physiological, and psychological correlates of voluntary exercise. *Health Psychology*. 2007;26:30-39.

would likely have better outcomes than a generic exercise intervention. The challenges to this kind of research include forging collaborations across disciplines and learning the languages of other disciplines.

Cost effectiveness

Behavioral interventions are often expensive and typically not covered by insurers. There is a need to "sell" behavioral interventions more effectively to policymakers. The obvious challenge is that prevention is more costly upfront, but there are some cost-effectiveness data from school-based programs and home-based nursing, for example, showing the merits of prevention versus costly biomedical solutions after disease onset.[31] More cost-effectiveness data, as well as comparative effectiveness data, are needed and, further, should be brought to the attention of policymakers as the current Administration's healthcare reform agenda is based in part on increasing the cost-effectiveness of America's healthcare system. Some participants noted that the same behavior change mechanisms utilized to change patient and provider behavior should be considered for changing policymaker behavior.

Dissemination of interventions

As behavior research produces more cross-cutting, multibehavioral interventions, better dissemination strategies will become increasingly important. A major inhibiting factor in dissemination is the lack of an effective delivery system to policymakers, providers, and consumers. Engagement with private businesses and entrepreneurs, and even marketers and advertisers, could reduce the burden on primary care providers to serve as a one-stop shop for screening and prevention. Everyday life venues, such as shopping malls, could be effective prevention delivery spaces. Alternately, harnessing new directions in healthcare delivery, such as electronic medical records, may allow for more seamless integration of tailored interventions that do not require as much provider effort.

Technology-based interventions

Many effective interventions are not routinely available in real-world settings due to translational barriers that include the cost of implementation, limited staffing resources, problems ensuring fidelity, and difficulty meeting the demand in some settings. In order for clinical research to have a larger public health impact, innovative dissemination solutions are needed. Technology-based interventions hold great promise for cost-effective, wide dissemination of evidence-based interventions and can apply to an array of health behaviors. They allow complex interventions to be delivered with fidelity at a low cost and readily enable tailoring to special populations. Most of the cost of the interventions is upfront, and long-term sustainability requires limited funding. In the areas of substance abuse and related risk behaviors, well-developed technology-based interventions have been found to be as efficacious as *in vivo* interventions delivered by highly trained therapists/educators, are cost effective, and are widely accepted by target populations. The possible means of intervention include the Internet, personal mobile sensing devices for more on-demand interventions, and online social networks to reach a greater number of people and exploit the infrastructure and dynamics of such networks. Participants cautioned, however,

[31] Aos S, Lieb R, Mayfield J, Miller M, Pennucci A. *Benefits and Costs of Prevention and Early Intervention Programs for Youth*. Olympia, Washington: Washington State Institute for Public Policy. 2004. Available at http://www.wsipp.wa.gov/pub.asp?docid=04-07-3901

that technology-based interventions are not a "magic bullet." They will work for some but not all and not necessarily in the way that the interventionist expects.

Financial incentives

Behavior analysis and behavioral economics recognize the important role that incentives play in changing voluntary behavior, including health-related behavior. Controlled clinical trials and meta-analyses demonstrate that incentive-based interventions are highly effective in changing substance use and other health-related behavior.[32] Financial incentives also provide an interesting conceptual opportunity for understanding the irrationality involved in decision making around health. For example, considering the fundamental biological urge a mother has to protect her fetus, why would a pregnant smoker quit for contrived incentives but not for the naturalistic incentive of a healthy baby? A thorough understanding of this question based on principles of behavior analysis, behavioral economics, and neuroeconomics could increase understanding of chronic health disorders for which behavioral factors are proximal causes.

Treatment adherence

Patient adherence to treatment is a longstanding problem that cuts across disease categories, populations, and treatment regimens and is a major cost contributor in the U.S. healthcare system. There are a wide range of adherence estimates within clinical settings, from 20 to 80 percent. The temporal trend for adherence shows a rapid decline within the first 3 months of treatment. The problem is one of both patients and providers; providers themselves are only about 50 percent adherent to the prescription recommendations within treatment guidelines.[33]

There are a number of issues that have stalled the study of improving adherence. The first is a measurement problem; that is, much of the research is reliant on patient self-report measures, and these can be quite variable, which makes it difficult to identify correlates or moderators of adherence. Patients themselves are not always aware of their poor adherence, and when they are, they often report forgetting as the major problem inhibiting their adherence to treatment. In intervention studies that have been useful in improving adherence (most notably, regimen simplification), effect sizes are modest. Patients exhibit relatively low levels of health literacy and high rates of comorbidities (over half of individuals with one chronic disease have at least one other chronic disease) with multicomponent treatment regimens (the average person is on six medications with varying schedules). Multiple medication regimens are often embedded in a variety of lifestyle modifications required by the patient, and there is overreliance on the patient to manage all of these treatments. These problems present a variety of areas in which basic science is needed to help improve research on patient adherence; namely, the science of self-report, cognitive function and compensatory strategies, the relationship between beliefs/attitudes and behavior, teaching and learning strategies, and self-management. Except for lowering the

[32] Lussier JP, Heil SH, Mongeon JA, Badger GJ, Higgins ST. A meta-analysis of voucher-based reinforcement therapy for substance use disorders. *Addiction*. 2006;101(2):192-203.

Heil SH, Higgins ST, Bernstein IM, Solomon LJ, Rogers RE, Thomas CS, Badger GJ, Lynch ME. Effects of voucher-based incentives on abstinence from cigarette smoking and fetal growth among pregnant women. *Addiction*. 2008;103(6):1009-18.

Volpp KG, Loewenstein G, Troxes AB, Doshi J, Price M, Laskin M, Kimmel SE. Financial incentive-based approaches for weight loss: a randomized trial. *JAMA*. 2008;300(22): 2631-7.

[33] Mitchell AJ, Vaze A, Rao S. Clinical diagnosis of depression in primary care: a meta-analysis. *The Lancet*, 22 August 2009; 374(9690):609-619.

price of copayments, the effectiveness of most strategies employed to encourage adherence is modest. There is a general sense that information by itself is not effective, which may or may not be true, but it is true that for certain populations (limited English language, low-income, etc.), improved methods for explaining conditions and medications are needed. These populations are more likely to be lower in health literacy and numeracy, which have been linked to lower levels of adherence.[34]

Addiction has been called a chronically relapsing condition. Despite the availability of effective methods for treating substance use and alcohol problems, maintaining changes over time has proven elusive; approximately 40 to 60 percent of patients return to substance use in the first year and approximately 80 percent drink at least once in the first year, all following good treatment.[35] More attentive studies of relapse processes for addictive behaviors are needed to understand the processes in the moment and in the individual's context. Extant plots of relapse data suggest that traditional analyses fail to capture individual differences in behavior outcomes, leading to null findings. Discontinuity in behavior is hard to capture in a linear, continuous model; mixed modeling approaches as well as dynamic systems models were suggested as alternatives. For example, to understand the various predictors, risk, and protective factors that affect relapse, a theory was developed suggesting that relapse is a complex system, and within any one context, all of these processes (within the realms of tonic processes and phasic responses) might be operating for any one individual and might change over time.[36]

One possible intervention model is to combine three elements that are usually presented as separate interventions: (1) Preparing people for behavioral antecedents (are there common triggers across behaviors?), (2) brain-targeted interventions (e.g., pharmacotherapy), and (3) consequences (continued reinforcement beyond intensive treatment, perhaps at the community level). In the disease model of relapse, it is characterized as "all or none." A less black-and-white model that informs people that relapse is normative could be helpful to allay the abstinence violation effect. This model also questions whether the idea of not talking about relapse in hopes that people will avoid it is really sustainable.

The concept of "urge surfing" was also introduced, which allows clients to learn alternative, nonreactive (e.g., breathing) responses to weaken the intensity of urges over time.[37] This is part of the work in mindfulness-based relapse prevention, which is being used by researchers in different domains (depression, stress). The program teaches participants meditation techniques as a sort of metacognitive coping skill. In the first study comparing mindfulness-based relapse prevention with treatment as usual in individuals with addictions after a treatment intervention, the more depressed the patients were the more intense their cravings. Mindfulness training successfully disassociated these two mediators in the experimental group.[38]

[34] Reyna, et al. (in press).
[35] Witkiewitz K, Marlatt GA. Relapse prevention for alcohol and drug problems: that was Zen, this is Tao. *Am. Psychol*. 2004;59(4):224-35.
[36] Ibid.
[37] Ostafin BD, Marlatt, GA. Surfing the urge: Experiential acceptance moderates the relation between automatic alcohol motivation and hazardous drinking. *J. Social & Clinical Psychology*, 2008, 27, 426-440.
[38] Work of G. Alan Marlatt and colleagues.

Scientific infrastructure needs

Foster transdisciplinary and multilevel approaches

Advances in the science of behavior change require a transdisciplinary and multilevel approach. Institutional silos, conservative review panels, and lack of an incentive structure are some of the oft-cited reasons why transdisciplinary research does not thrive, and participants considered how the NIH might foster this area. For example, the NIH could consider targeting support of mediators as outcomes or require researchers to approach a problem at multiple levels of analysis. There was a call to develop sustainable structures for cross-disciplinary collaboration, which is not currently rewarded by existing institutions. How researchers are trained generated considerable discussion. In academic institutions, training is predominantly unidisciplinary, and the pressure to be so increases as one seeks advanced training and in the early years of researching and publishing.

However, to counter concerns that transdisciplinary training might compromise depth in pursuit of breadth, there were advocates for continuing with unidisciplinary training but enhancing it with exposure to transdisciplinary work, a new feature of some NIH training grants, as well as for both kinds of training. In his book, *Methodology and Epistemology for Social Science*, Don Campbell talks about a "fish scale model of collective omniscience" as a way to overlap the many narrow specialties of research, another way of imagining a transdisciplinary approach.

Participants also called for greater interplay between research on the basic mechanisms of change and clinical interventions. Suggestions for accomplishing this included not only exposing students early in their training to other disciplines but also facilitating repeated basic researcher/applied researcher exposures and collaborations over time; for example, with face-to-face meetings, online databases, and/or virtual networks such as the MacArthur Foundation research networks. In the same vein, participants suggested that the NIH create funding mechanisms for transdisciplinary teams that are less project focused to allow freedom for iterative development of ideas. In essence, some teams of researchers need a longer incubation period because the science grows from the collaboration rather than the inverse. One suggestion was that small conference grants with participants from multiple disciplines could foster ongoing, robust collaboration across disciplinary lines.

Encourage a common taxonomy

A common language for behavior change research, particularly as researchers from different disciplines or from a basic and applied approach collaborate, is critical. This includes a taxonomy for operationalization of core behavioral processes and mechanisms and common metrics of measurement. Suggestions for developing a common taxonomy included developing wiki-style dictionaries, supporting smaller meetings under planning grants, and requiring glossaries for each grant.

Expanding the disciplines represented in PubMed to include other areas of relevance to behavior research (e.g., economics) could be a useful means of bringing work in other disciplines to the attention of behavior change researchers working in a biomedical framework.

The National Cancer Institute–supported cancer Biomedical Informatics Grid (caBIG) is an example of an information platform offering a common database of measures and constructs that

will be downloadable, interoperable, and accessible to both basic scientists and clinical investigators. Complementing caBIG is development of a wiki-style toolkit containing best practices for facilitating team science.

Recognize scientific review challenges for integrated projects

Participants observed that NIH study sections are generally too conservative in their reviews of high-risk grants, and reviewers tend to criticize methods that are not at the cutting edge in one narrow area rather than seeing the big picture goal of a more integrated approach. Part of the issue may be in part due to the fact that the members are not from diverse disciplines; studying study sections to understand their dynamic structure was put forward for consideration. NIH staff also noted a number of funding mechanisms better suited for supporting the work of interdisciplinary teams, such as centers grants and program project grants.

Strengthen public health infrastructure

The effect of behavioral inertia should not be underestimated. Much can be done to make the healthier choice the easier choice. For example, defaulting people into receiving their prescriptions by mail order could increase adherence. Ultimately, the entire structure of the healthcare system should be considered to facilitate healthy behaviors and remove barriers to these behaviors. Even long-term adherent patients will stop their medications if the copay increases; notably, a $10 reduction in copay roughly translates into a 10 percent increase in adherence.[39] While this improvement seems relatively modest, such improvements are difficult to achieve with other strategies.[40] While negative copayments have not been studied, a similar strategy was employed with favorable results in smoking cessation; i.e., people were paid to quit smoking with increasing incentives for longer term adherence.[41]

NEXT STEPS

The highly influential role of behavior in health outcomes suggests that better understanding about the basic mechanisms underlying behavior change promises substantial improvements in public health and potential for cost savings. Since NIH Institute directors identified advancing the science of behavior change as a top priority for NIH-wide research efforts 2 years ago, there has been enormous interest by NIH staff to bring together scientists from a wide range of disciplines to radically move the science forward. This meeting represented the coalescing of those efforts to help the NIH shape and develop the research agenda for a cross-NIH, cross-disciplinary initiative on the science of behavior change. The issues and ideas put forth by meeting participants stimulated innovative thinking and new collaborations. Committing to research that will lead to transformative breakthroughs in the understanding of behavior change is an investment that can dramatically change the landscape to ultimately benefit the health and well-being of all people.

[39] Goldman DP, Joyce GF, Escarce JJ, Pace JE, Solomon MD, Laouri M, Landsman PB, Teutsch SM. Pharmacy benefits and the use of drugs by the chronically ill. *JAMA*, 19 May 2004; 291(19):2344-2350.
[40] Behavior change, such as smoking cessation, has been achieved with Theory of Reasoned Action and other behavioral approaches. See Fishbein M. A reasoned-action approach to health promotion. *Medical Decision Making*, 2008;28:834-844.
[41] Work by Kevin Volpp and colleagues.

APPENDIX 1

Meeting Agenda

Rev. June 11, 2009

June 15 (Monday) — Grand Ballroom

7:30 a.m.	**REGISTRATION CHECK-IN/CONTINENTAL BREAKFAST**	
8:30 a.m.	**WELCOME AND OPENING REMARKS**	**Richard Hodes** **Patricia Grady** **Richard Suzman**
8:45 a.m.	**ACQUISITION AND PREVENTION OF BEHAVIOR**	**NIH Moderator: Mark Willenbring**
8:50 a.m.	**Overview of Applied/Clinical Issues in Prevention/Acquisition**	**Michael Cummings**
9:00 a.m.	**Panel IA** **Acquisition and Prevention of Behavior: Basic Science**	**NIH Facilitators:** **Lis Nielsen & Deborah Olster**
	Developmental Perspectives: Risk and Resilience	**BJ Casey**
	Gene-Environment Interactions	**Terrie Moffit**
	Neurobiology of Decision Making	**Read Montague**
	Emotion Regulation, Self-regulation	**Kevin Ochsner**
	Behavioral Economics and Consumer Decisions	**Eric Johnson**
	Social Influence and Social Networks	**Thomas Valente**
10:15 a.m.	**BREAK**	
10:45 a.m.	**Panel IB** **Acquisition and Prevention of Behavior: Applied/Clinical Science**	**NIH Facilitators:** **Kara Hall & Jeff Evans**
	HIV Prevention/Designing for Adoption	**Mary Jane Rotheram-Borus**
	Causes and Prevention of Multiple Problem Behaviors	**Brian Flay**
	Behavioral Economics of Addictive Behavior Change	**Jalie Tucker**
	Development of Social Competence/Prevention of Developmental Disabilities	**Craig Ramey**
	Stigma: Suicide, Mental Illness and Other Health Problems	**Bernice Pescosolido**
12:00 p.m.	**Methodological Commentary**	**William Follette**
12:10 p.m.	**Basic Science Commentary**	**Colin Camerer**
12:20 p.m.	**Applied/Clinical Science Commentary**	**Kenneth Sher**

June 15 (Monday) – Cont'd

12:30 p.m.	**LUNCH** ***Remarks by David Cutler*** ***Otto Eckstein Professor of Applied Economics, Harvard University***	**Rockville/Chevy Chase/Bethesda/Potomac**
2:00 p.m.	**CHANGING EXISTING BEHAVIORS**	**NIH Moderator: Lisa Onken**
2:05 p.m.	**Overview of Clinical/Applied Issues in Changing Existing Behaviors**	**Bonnie Spring**
2:15 p.m.	**Panel IIA** **Changing Existing Behaviors: Basic Science**	**NIH Facilitators:** **Jonathan King & Colleen McBride**
	Behavioral Genetics	**Janet Audrain McGovern**
	Developmental Neuroscience	**Ronald Dahl**
	Behavioral Economics	**Brian Wansink**
	Dynamic Social Networks and Mathematical Models	**Carlos Castillo-Chavez**
	Cognition, Learning, Decision Making	**Valerie Reyna**
	Social Cognition and Stereotyping	**Susan Fiske**
3:30 p.m.	**BREAK**	
4:00 p.m.	**Panel IIB** **Changing Existing Behaviors: Applied/Clinical Science**	**NIH Facilitators: Joan Wasserman & Christine Hunter**
	Promoting Positive Behavior in Children/Adolescents	**Margaret Grey**
	Decreasing Risk Behavior Using Technology-based Interventions	**Lisa Marsch**
	Incentive-based Substance Abuse Change	**Stephen Higgins**
	Changing Alcohol Abuse	**Richard Longabaugh**
	Changing Exercise Behavior	**Angela Bryan**
	Improving Sleep	**Richard Bootzin**
5:15 p.m.	**Methodological Commentary**	**William Revelle**
5:25 p.m.	**Basic Science Commentary**	**Stephan Hamann**
5:35 p.m.	**Applied/Clinical Commentary**	**Richard McNally**
5:45 p.m.	**RECEPTION/DISCUSSION**	**Rockville and Chevy Chase**

June 16 (Tuesday) — Grand Ballroom

7:30 a.m.	**REGISTRATION CHECK-IN/CONTINENTAL BREAKFAST**	
8:30 a.m.	**MAINTENANCE OF BEHAVIOR**	**NIH Moderator: William Riley**
8:35 a.m.	**Overview of Clinical/Applied Issues**	**G. Alan Marlatt**
8:45 a.m.	**Panel IIIA** **Maintenance of Behavior: Basic Science**	**NIH Facilitators:** **Minda Lynch & John Glowa**
	Behavioral Economics and Decision Making	**David Laibson**
	Learning, Memory and Metacognition	**Janet Metcalfe**
	Social Neuroscience Perspectives	**Peter Hall**
	Real-time fMRI Feedback for Subject Learning	**Christopher deCharms**
	Social Networks and Social Engagement	**Thomas Glass**
	Computer Science and Engineering Perspectives	**Stephen Intille**
10:00 a.m.	**BREAK**	
10:30 a.m.	**Panel IIIB** **Maintenance of Behavior: Applied/Clinical Science**	**NIH Facilitators:** **Susan Czajkowski & Melissa Riddle**
	Treatment Adherence	**Jackie Dunbar-Jacob**
	Social Ecological Models of Maintaining Exercise Behavior	**James Sallis**
	E-Health	**M. Christopher Gibbons**
	Oral Health Behavior	**Jane Weintraub**
	Alcohol Relapse and Maintaining Abstinence	**Katie Witkiewitz**
	Maintaining Smoking Abstinence	**Saul Shiffman**
11:45 a.m.	**Methodological Commentary**	**Lisa Dierker**
11:55 a.m.	**Basic Science Commentary**	**Reid Hastie**
12:05 a.m.	**Applied/Clinical Commentary**	**Michael Otto**
12:15 p.m.	**LUNCH**	**Senate Suites**

June 16 (Tuesday) – Cont'd

1:30 p.m.	**BREAKOUTS** • *What basic research areas could lead to the greatest transformation of the Science of Behavior Change in the next 5 years?* • *How can we develop a common language to facilitate communication between basic and applied scientists in the Science of Behavior Change?* • *What approaches to behavior change are the most ripe for broader translation in the near future and why?*	**Breakout 1** **Bethesda/Potomac** **Breakout 2** **Montgomery/Democracy** **Breakout 3** **Pooks Hill/Kensington** **Breakout 4** **Rockville/Chevy Chase**
3:00 p.m.	**BREAK**	
3:15 p.m.	**BREAKOUT SUMMARIES**	**Jonathan King**
4:45 p.m.	**WRAP UP**	**Richard Suzman** **Patricia Grady**
5:00 p.m.	**ADJOURN MEETING**	

APPENDIX 2

Attendees

Rev. June 26, 2009

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