Research on the General Principles That Underlie Behavior is Central to the Mission of the National Institutes of Health

*Report prepared by the Federation of Behavioral, Psychological, & Cognitive Sciences' "Committee for the Exploration of Health Relevance in Basic Behavioral Science"**

May 2005

***Committee members:** Peter Balsam (Columbia University & Barnard College), Mahzarin Banaji (Harvard University), Sheldon Cohen (Carnegie Mellon University), Daniel Kahneman (Princeton University), Jennifer Lerner (Carnegie Mellon University), James McClelland (Carnegie Mellon University)

This brief document seeks to characterize the scope of basic behavioral science and to make the case that research within this science is central to the overall mission of the National Institutes of Health.

What is Basic Behavioral Science?

Basic science has been defined as research aimed at understanding the fundamental aspects of phenomena and of observable facts. Basic behavioral science is aimed at understanding the fundamental principles that govern behavior; the cognitive and emotional processes that underlie behavior; and the effects of social context and experience on cognition, emotion, and behavior.

An example of a process at the behavioral level is the choice a person makes when confronted with options. These options could be a luxurious gas-guzzler vs. a fuel-efficient economy car, or a double bacon cheeseburger vs. a grilled chicken sandwich. Such choice opportunities arise in a wide range of contexts, including health relevant contexts, and it is one of the aims of behavioral science to discover the principles that govern the choices people make in these situations. A key finding from research in this area is that the choices people make depend heavily on whether the outcomes from the choices are framed in terms of gains or losses and on the uncertainty surrounding the outcomes. A theory explaining these framing effects, called Prospect Theory, has been used as the springboard for developing specific testable hypotheses about how to frame health-relevant choices, and a growing body of experimental results is now in hand that supports these predictions. The key point here is that the essential concepts, namely uncertainty, cost, and benefit, are defined at the level of the behaving individual operating in an external environment. They reflect relationships between actions and outcomes; they are not concepts that can be defined at a neural or genetic level.

While basic behavioral science is and should be connected to other sciences, it is a distinct and legitimate science in its own right. That is, there are principles and processes that must be understood in terms of the experiences people have and how these experiences shape their cognition, emotion, and behavior. The situation here is the same as it is for other sciences, including basic cellular science. Just as there is no doubt that cellular science is connected to other sciences such as biochemistry, there can be no doubt that new phenomena and processes arise at the level of the cell that are not present at other, lower levels. Understanding biochemistry contributes to a deeper understanding of cells, but it does not replace that understanding, since the cell is a complex system with many parts that function in an interdependent manner. So it is with behavior and the science of behavior: Other sciences, such as neuroscience and genetics, will surely enrich our understanding of behavior, but the science of behavior cannot simply be reduced to neuroscience or genetics, because there are important processes and principles that arise at the behavioral level.

It is worth distinguishing basic research from another type of research, which might be called “disease oriented”. Disease-oriented research includes work characterizing the nature of a disease or disorder, or work on interventions that will lead to specific health benefits, such as reduction of lung cancer. Work of these types is well represented in the portfolio of the NIH, and is of course central to its mission, and disease-oriented behavioral science research is no exception; funds are available for the detailed characterization of behavioral, cognitive and affective disorders and for the development of behavioral interventions that directly target specific health-relevant behaviors, such as smoking or drug use. In contrast, research addressing the general principles underlying behavior is experiencing a withdrawal of support. Yet this basic-science research is also vital to the mission of NIH, as we now explain.

Why is Research Addressing the General Principles of Behavior Relevant to the Mission of the National Institutes of Health?

Basic behavioral science is relevant to the NIH mission because success of disease-oriented research depends heavily on what has been learned from basic science, and further gains in understanding this basic science will produce important benefits for understanding and ameliorating diseases and promoting health. This is just as true for basic behavioral science as it is for basic cellular science.

1. Like cellular processes, behavioral, cognitive and emotional processes are key determinants of health. Smoking, engaging in risky sexual practices, taking drugs of abuse, eating healthy foods, and getting exercise are all essentially behavioral processes that have a dramatic influence on health. Similarly, perceived threats (whether real or illusory) and beliefs about the degree to which

the individual can control them affect levels of stress, which in turn have profound effects on health and mortality.

2. As with cellular functions, behavior, cognition and emotion depend on both endogenous and exogenous factors. For behavior, cognition, and emotion, social context and experience are especially important. Because of this, understanding how social context and experience affect cognition, emotion and behavior has important consequences for health. One clear example of the impact of social context on health is the evidence establishing a relationship between lower social status and an increased likelihood of becoming ill with a respiratory infection after receiving a controlled dose of a rhinovirus.

3. As in cells, general principles and processes are at work in behavior and in mediating the effects of experience on behavior, across all phases of life and all aspects of behavior, including health- and disease-relevant aspects. While there are differences between cells in different organs and at different life stages, it is clear that our understanding of these domain- and situation-specific details draws crucially on our understanding of the general principles governing cellular processes. It is no different with behavior. While there remains no universal consensus as clear as the one surrounding the 'Central Dogma' of cellular function, a growing consensus surrounds the view that the internal processes underlying behavior are continuous and intrinsically variable; that they involve the simultaneous and graded influence of multiple constraints or sources of information; and that they adapt gradually in response to experience. These ideas are in stark contrast to the ideas that pervaded the field 25 years ago, in which mental processes were thought of as discrete and uni-directional, and were based on categorical rules acquired in all-or-none fashion or discovered in a 'Eureka moment'.

4. As in any other science, the processes and principles are not self-evident. Our current understanding arises from basic research, and basic research is required for their further elucidation. Perhaps this point is the most important single point to make about behavioral science, since there is a tendency to think that the principles of behavior are self-evident. In fact, this is far from the case. Here we give one example; it and others are described further in the attached background materials: Basic science research on learning has now made clear that a behavioral tendency (what is experienced as an ‘urge’) can never be completely eliminated once established (e.g. by providing reward for engaging in the behavior). While it is possible to learn to suppress the tendency, the suppression is tied to the context in which it was acquired, and does not transfer effectively to other contexts. This context-dependency of the learned suppression is not self-evident --- it was discovered from basic research.

5. As in other life sciences, the development of new and more effective health interventions depends on findings from basic research aimed at elucidation of the general principles. Continuing the example above, our knowledge that the suppression of behavioral tendencies is context-specific explains why behaviors that are eliminated in treatment settings often fail to transfer back into the real world, and suggests new avenues for treatment research aimed at finding ways of overcoming the context-specificity of the learned suppression.

6. Just as in the case of scientists who are trained to investigate cells, scientists trained to investigate behavior, cognition, and emotion are essential for further progress on the general principles and for their interdisciplinary and translational utilization. The cross-cutting nature of the research and of the expertise needed for it strongly favors a model in which basic behavioral science research training is viewed as an essential springboard to translational and interdisciplinary investigation. The expertise and training that allows a scientist to measure and promote health-relevant social and behavioral factors and to evaluate similar work by others are not disease-specific---they are broadly applicable to all diseases and health-relevant behaviors at all life stages. This sort of training was previously promoted within the National Institute of Mental Health and is no longer supported anywhere within the NIH. It is essential to the future enhancement of behavior-based treatment of illness and promotion of health that such programs be vigorously supported.

Appended to this overview is a set of background materials elaborating and further documenting some of these points.

Implications

Because of its central relevance to all aspects of health, support for basic behavioral science at NIH should follow the same model as support for basic research on cellular biology. Basic behavioral and social science is cross-cutting science relevant to all aspects of health, and NIH should find ways to provide support for this science. We stress that basic behavioral and social science should not be viewed as an alternative to behavioral science research that targets a specific disorder or an individual NIH Institute. On the contrary, support for research on the general principles underlying behavior would be specifically intended to complement and enhance disease-specific research by providing the crucial basic science insights that would make the institute-specific research more productive and beneficial. Insight into general principles that then impact upon all areas of science has come from a focus on the central scientific questions per se. The work of Watson and Crick was basic science, carried out to understand the basic mechanisms through which cells govern their own activity and replication, yet this work has been of fundamental significance for the health sciences. So too the work of basic behavioral scientists has informed our understanding of the processes underlying a wide range of health-relevant aspects of behavior.

A further, essential point is that NIH should find ways of supporting training in basic behavioral science. This training is essential for the creation of researchers who will increase our understanding of all of the specific topics this science addresses. Equally importantly, this training will continue to provide outstanding researchers with the deep knowledge and understanding needed to translate an understanding of behavior into practical applications relevant to health.

Basic behavioral and social science is every bit as relevant to health as basic cellular science. An affirmation of NIH support for this science would acknowledge the central role of behavioral and social processes in health and provide a vehicle for the discovery of new insights into behavioral and social processes that will be crucial to promoting the health and well being of the public.

Examples of Basic Behavioral Research and Health-Relevant Applications

Basic Research on Learning and Perception

This area of basic research has been a source of applications since the 1950s. It thus provides an opportunity to illustrate how basic knowledge can seed new applications which evolve into important therapeutic tools. It also illustrates the need for continued support for basic research to ensure a constant source of treatment innovation and application.

The Past

Historically, there has been a strong relationship between basic research on learning and therapeutic application. Behavioral therapies such as desensitization for fears, social skills training, and the use of symbolic communication with autistic children trace their history to basic work on Pavlovian and Operant conditioning in animals. More recent developments in this tradition have given rise to what is referred to as cognitive behavior therapy. These behavioral approaches to intervention are now established as effective treatment and maintenance components in dealing with many problems including anxiety disorders, depression, ADHD, bulimia and anorexia. In some cases, such as borderline personality disorder, it is the only demonstrably beneficial treatment. It would have been difficult to anticipate that the basic behavioral principles discovered by studying learning in animal models would have evolved into such powerful therapeutic tools.

The Present

Even now basic learning research conducted in the last 15 years is being translated into therapeutic approaches. Mark Bouton, an NIMH-supported experimental psychologist at the University of Vermont, has investigated how old learning can be overcome by new experiences. Specifically, his laboratory has investigated *extinction*, a basic behavioral process that is probably involved in many forms of therapy, and explicitly involved in exposure treatments used in cognitive behavioral therapy. They have discovered that these treatments do not destroy the original learning, but replace it with new learning. That means that when maladaptive reactions are modified by therapy they are not erased. The new learning seems to be especially dependent on the situational or contextual cues for retrieval. This means that if the context is changed or if the person is returned to the context in which the original experience occurred the original reactions are likely to return and cause relapse. Some of the recent basic research has addressed theoretical issues about how to optimize new learning in a way to make it more permanent and less subject to relapse. They have just begun to apply this work to understanding and treating panic disorder as well as post-traumatic stress disorder. The translation of this basic research to therapy seems very timely in light of the anticipated need of soldiers returning from Iraq.

A second example of very basic work that is now being translated into experimental therapeutic treatments comes from the NIDA supported laboratory of Shepard Siegel at McMaster University. Many scientists and therapists agree that the problem for most drug addicts that have undergone treatment is that they are very likely to relapse. Anyone who has stopped drinking, smoking or taking drugs can attest to the fact that cravings can be intense and that they can even occur years after quitting. Siegel's laboratory has shown that these cravings are learned responses –learned through the principles of Pavlovian conditioning. Apparently, the situations in which drugs are taken, the friends who are present, and even the feeling of starting to take a drug all become associated with the drug and come to evoke craving. It has now been shown in laboratory settings with animal models that these learned cravings do indeed follow the laws of Pavlovian learning and play a large role in relapse. Because the cravings are learned responses new tactics for lowering the difficulty of quitting and decreasing the likelihood of relapse are being derived from basic research on Pavlovian conditioning.

The Future

While necessarily speculative, it is instructive to envision how basic research might be used to solve practical problems. One area that holds exciting possibilities is in basic research on learning and time perception. There is an emerging consensus that most animals perceive and encode temporal information about their experiences. They seem to automatically store quantitative information about event durations and precise temporal information about the relationship between events. Furthermore, this information can be used in very flexible ways to solve problems. With the support of NIMH ongoing research in laboratories such as Peter Balsam's at Columbia University and Randy Gallistel's at Rutgers University are seeking to understand all of the underlying processes. How is time perceived? How is it encoded and retrieved? How is temporal

information used to make decisions about whether, when, and how to respond? The work is leading to new understandings of the mechanisms of learning and how temporal representations guide behavior. At the core is the idea that time is always a fundamental aspect of what is learned.

From this point of view, for behavior to be adaptive it must be tuned to the temporal structure of events. Consequently, behavior can be maladaptive because of distortions in temporal information processing. While it is more usual to view the timing problems as a symptom of an underlying disorder it is possible that the timing distortion is the cause of the symptoms. For example, distortions in timing and anticipation may contribute to a number of mental health disorders. Impulsivity in ADHD, drug-taking, and other high-risk behaviors may result from a failure to anticipate long-term negative consequences. In schizophrenia there are well documented distortions in timing, sequencing and anticipation. Similarly, in depression there is an inability to anticipate positive future events and a distorted time sense. Focusing on the underlying processes will provide a clearer understanding of the disorders and new ideas for treatment.

Another application of the timing work comes from the potential to use timing tasks as diagnostic tools for early diagnosis of neurological and behavioral disorders. For example, Chara Malapani, a neurologist at Columbia University with previous support from NIMH has shown that there are timing disturbances that are unique to Parkinsons disease. When off of their medication, patients who are asked to remember two intervals remember the short time as longer and the long time as shorter. So far as we know this pattern of distortion is unique to Parkinsons. It is thus possible that simple and inexpensive timing tasks could be used to screen for certain disorders – even before significant motor symptoms develop. This could be a significant advance in allowing for early treatment of the disease. Additionally, timing tasks might make turn out to be excellent procedures for screening for the efficacy of new drugs and for monitoring the efficacy of different treatments in patients.

So it is possible that basic research on learning and temporal information processing will provide us with insight into the character of disease and new avenues for diagnosis and treatment. But, unless we support the basic research we will never know.

Socioeconomic Status and Health

This example presents a puzzle with tremendous public health implications. It illustrates how common processes and principles underlying the influences of psychosocial and behavioral factors on disease cut across the missions of all NIH institutes. Additionally, this example highlights the importance of basic behavioral research for generating hypotheses relevant to solving public health issues.

The graded nature of the association of socioeconomic status (SES) and health presents a puzzle in regard to how SES influences health.

Increasing socioeconomic status, whether measured in terms of income, education or occupation has been associated with decreasing rates of mortality and morbidity from almost every disease condition. The association between increasing SES and increasing health is not merely a product of poorer health and well-being among those with the lowest income and education. Instead, it is graded with every increase in SES association associated with an increase in health status. It is also not solely due to the relationship between income and access to healthcare as the graded association between SES and health is found in both countries with and without government funded medical care.

The association between SES and health is subject to alternative causal explanations (e.g., reverse causation [drift hypothesis] and other third factors that might cause both lower SES and poorer health), however, the most plausible explanation for this association is that SES directly effects health and well-being. For example, the changes in SES that accompany divorce, not divorce per se, predict poorer health outcomes.

The graded nature of the SES and health relation presents a puzzle in regard to how SES influences health. Traditional explanations for the association of lower SES and poor health include less access to and poorer quality of health care, greater environmental risk, poorer nutrition, and poorer health practices among lower SES groups**.** Although these are plausible explanations for why persons lowest on the gradient suffer from poorer health, it is less clear why observed differences occur on the middle and highest parts of the gradient.

Current thinking is that the primary components of SES, including income, education and occupation are enmeshed in key domains of life and hence shape one's life course, e.g., the physical and social environments which affect psychological development and ongoing mood, affect and cognition. Moreover, the health practices and psychological characteristics that emanate from these factors are thought to account for parts of the gradient relation, particularly the decreased risk that occurs at the middle through highest levels of SES. Behavioral factors that may potentially contribute to decreasing SES causing poorer health include smoking, alcohol consumption, substance abuse, less physical activity, and poor sleep. Psychosocial characteristics include depression, anxiety, hostility, psychological stress and lack of personal control and social connectedness.

Basic research on feelings of personal control provides insight into the graded link between SES and health.

Clearly our understanding of the role that behavioral and cognitive processes play in health is an essential aspect of understanding the health disparities associated with decreases in SES. This perspective has its roots in basic behavioral research in stress, personal control, social connectedness, and depression. An example is the development of the concept of control. Our understanding of the control concept is the product of nearly 50 years of basic behavioral science research. Work on the importance of control dates back to Joseph Brady's classic study published in 1958 demonstrating that his "executive" monkeys, those who were allowed to terminate electric shocks with a behavior response, developed ulcers, whereas those without control over shock termination did not. There are two interesting points about this result. First, Brady was not studying ulcers, but instead, this was a serendipitous finding in a study of the effects of shock on learning. Second, his conclusion that control was detrimental turned out to be incorrect, probably because of his experiment wasn't adequately designed (or intended) to test this hypothesis. Even so, it triggered interest in the concept of control that in time led to the understanding of this important concept. Subsequent work by Jay Weiss showed that having control over electric shock (having coping responses available) actually decreased detrimental physiological responses including ulcers, as long as feedback was available as to the effectiveness of each coping response. It was coping without feedback that caused ulcers. Work

on more general psychological and physiological implications of lacking control followed. For example, Martin Seligman and his colleagues found that repeated exposures to situations where outcomes were independent of how one responded (they labeled this “uncontrollability”) resulted in deficits in motivation, learning, and in negative emotional responses. They called this phenomenon “learned helplessness.” Those experiencing helplessness “gave up” on subsequent tasks, were unable to learn that they could control other situations, and experienced depression and anxiety. Learned helplessness later was developed into a theory of underlying cause of depression. At the same time, David Glass and Jerome Singer were developing their work on the role of “perceived” control in what they labeled “stress-aftereffects.” In short, they demonstrated that learned helplessness could be created by manipulating people’s “perceptions” of control, irrespective of whether actual control existed or not. These and other basic research studies led to subsequent work demonstrating that a lack of control (mastery) was associated with the development of poorer mental health outcomes and that a lack of control in work settings was associated with greater risk for cardiovascular disease. This has led Michael Marmot and others to suggest that associations of SES with a broad range of physical health outcomes are to some extent attributable to increased feelings of control associated with increasing SES.

If this hypothesis holds up it may stimulate new approaches to improving public health that are based on arranging environmental and contextual factors to give people and increased sense of control.

The Implicit Association Test:
A Case Study of the Applications of a Basic Method to Measure Associative Memory

This example illustrates how research can lead to the development of tools and methods with health related applicability far from the basic research question they were designed to address.

The Implicit Association Test is a method to assess the strength of mental associations. It is itself derived from basic research conducted decades prior to its development on the idea of associative learning. The IAT was developed by Tony Greenwald at University of Washington in collaboration with Mahzarin Banaji at Harvard University and Brian Nosek at University of Virginia. The test was created in response to social psychology's dissatisfaction with the sensitivity of existing survey-type measures that rely purely on verbal self-report. In domains where the sensitivity of the topic is high (such as expressing racial attitudes or reporting on one's sexual or addictive behaviors) the need for such a tool was imperative. The method allows the detection of cognition and emotion that is not within a person's ability to control, it produces large effects that are noticeable without more than a stop watch to measure it, and most important of all, it has transformed the way in which a scientist interested in measuring unconscious mental processes can now measure such representations of thought and feeling. Whether the mental process is one that is suppressed because of its sensitivity or because human consciousness only permits access to a thin slice of underlying material, the IAT allows a new probe that overcomes several limitations of tools used for a century of research. This advance would not have been possible if the research scientists had been doing anything other than trying to fix a problem of measurement in their field. But doing so did generate a technology that is general, easy to administer, and for which a web application was immediately created.

The effects of the IAT invention have been felt in many areas – since its quite recent first publication in 1998, over 200 papers are available that use the technique to understand varied aspects of behavior that are crucial to assessing and guaranteeing a healthy nation – understanding pathology and treating mental health, understanding and overcoming the fact of health disparities, facilitating cognitive and affective neuroscience research on health, and revealing that the everyday decisions of ordinary patients and physicians contain biases of which they are unaware. Optimistically, the technique is now being used to show how such biases can be corrected, if they are made visible.

For example, the IAT has become an important tool for understanding psychopathology because the maladaptive cognitive processes that underlie the onset and maintenance of mental illness are involuntary. For example, modern theories suggest that the inability to terminate fear-evoking cognition may be the key to pathological anxiety. There is now evidence for implicit fear associations across a number of different anxiety concerns, including trait anxiety, anxiety sensitivity, obsessional concerns, panic disorder and specific phobias. Consequently, this method provides a valuable alternative to unreliable self-reports of patients. This method has been demonstrated to have diagnostic utility and to be a reliable measure of improvements with therapy. Work is currently underway to assess the utility of the technique in other serious mental illness including depression and panic disorder with the hopes that the method can be used to predict vulnerability to the onset of psychopathology and relapse. For example, research by Teachman has shown that individuals who are vulnerable to panic disorder showed implicit panic associations relative to a group low in anxiety sensitivity even before the onset of their first panic attack. Taken together, the emerging work shows that the IAT can offer new insight into those aspects of psychopathology that occur outside conscious awareness and conscious control that are critical to the onset, maintenance and recovery from serious forms of psychopathology.

In addition to this domain of obvious application, the IAT has been used now to understand disparities in health treatment – several studies are underway using it to assess the unintended but real stumbling blocks to providing equal treatment to all segments of society. Doctors and other health care professionals use the tool as part of their education in medical school, in continuing education and research to become aware of the disparity between their stated goals of fairness and their implicit or unconscious negative stereotypes. It is remarkable that this effective research tool is also an effective education tool.

It is evident that support of basic research (in part by NIMH) on social cognition has produced a tool with wide ranging applicability to health issues. The export of specific methods from basic research to applied domains is yet another way in which the basic work enables progress in solving health related problems.

Basic Research on Emotion and Decision Making

This summary illustrates the importance of an integrative and basic approach to research addressing emotional influences on decision making. Basic behavioral research in this domain has led to knowledge that applies across a wide range of health- relevant domains and across the lifespan of an individual.

Many health decisions must be made while patients, families and physicians are experiencing strong emotions. Basic research on how emotions affect decision making already suggests that emotions sometimes influence decisions in counterintuitive ways. For example, although it was once commonly believed that negative emotions – such as fear and anger -- tend to elicit pessimistic risk perceptions, recent studies reveal that anger actually elicits optimism. Such effects occur across a wide range of situations, even when the emotions should have no "rational" influence on the decisions at hand.

These findings emerged in recent lab experiments examining the basic processes of emotion and cognition. Already they have found diverse health applications – several of which were unexpected. Consider one application arising from a study examining the effects of the 9/11 attack on risk perception. In a nationwide field experiment led by Jennifer Lerner of Carnegie Mellon University, media stories that triggered anger elicited diminished risk perceptions and intentions to take precautionary measures; media stories triggering fear did the opposite. Astonishingly, as in previous basic laboratory studies, fear and anger had global carry-over effects on risk perceptions. For example, an anger- inducing media story concerning Arab celebrations about 9/11 caused participants to perceive significantly less risk of acquiring the flu! Moreover, anger reduced intentions to take health precautions, such as obtaining flu shots and containing possible biological contaminants.

Applications to problems of world health are emerging from this nascent line of research on basic processes of emotion and cognition. NATO Headquarters (Brussels) brought Lerner to address an audience of scientists, practitioners, and NATO ambassadors who are working on ways to improve risk communication in the face of terrorist attacks. Such application could never have been accomplished were these basic processes of emotion and risk perception studied only in the context of a particular patient population. Most recently, this very same line of work has been highlighted by scientists at the National Cancer Institute who have argued that this work should be a basis for building better models of cancer decision making.

Like anger and fear, sadness can also carry over from one situation to others, exerting global effects on decisions. Lerner's group has also done basic behavioral studies with college students, MBA students, and community samples, revealing that sadness from one situation carries over, making people willing to pay significantly more to buy something than if they were in a neutral state. Interestingly, the influence of emotions is much stronger among adolescents, possibly explaining some underpinnings of adolescent risk taking. While basic biobehavioral studies in Lerner's lab explore these processes, scientists at NIAAA have begun to apply Lerner's work as a way to understand reward seeking processes in adolescence. Specifically, they aim to apply this basic science to the problem of underage drinking—arguably the number one health problem for youth.

Finally, apart from the applications mentioned above, these cognitive-emotional states may have more direct influences on health outcomes. Drawing on the basic emotion-cognition studies, Lerner's research group hypothesized and found that facial expressions of fear and anger, respectively, relate to opposing patterns of cortisol secretion. Cognitive appraisals mediate the link from facial expression to neuroendocrine response. Thus cognitive/emotional processes influence hormonal stress responses and their subsequent influence on a wide range of health outcomes.

Whereas the classic conception of stress involves undifferentiated negative affect and corresponding biological reactivity, Lerner's work disaggregates stress into emotion-specific, contrasting patterns of biological response. Because stress is implicated in major morbidity and mortality threats, identifying and understanding behavioral and physiological indices of normal and pathological stress reactivity is important for improving both physical and mental health.

In sum, fundamentally similar processes of emotion and cognition are operative under a wide range of situations. A single theoretical model of these processes – supported in part by NIMH – underlies all of the work reviewed here. The most cost-effective and scientifically sound way to develop this research is to continue work on the model and these basic processes. Such work will lead to better health-related decision making and to better understanding of the mechanisms whereby cognitive-emotional factors lead to disease and suboptimal responses to national health threats.

Principles of Cognitive Processing

This example illustrates how quantitative modeling of basic behavioral research leads to the emergence of new general principles and how these principles may then be applied to understanding a range of diseases and disorders. Moreover, the example illustrates how vulnerable this type of research can be when it does not fall directly within the mission of a single institute.

In the 1970's, research on human cognitive processes took place within the context of the discrete-stage theory, in which the time between a stimulus and a response was thought to be taken up be a sequence of discrete and successive stages of processing. For example, the time it takes to identify a word was thought to consist of an initial stage of perception, a subsequent stage of letter identification, and a final stage of list search, in which the word is located in a mental word list or dictionary. However, at the end of the preceding decade, the seeds were sown for the demise of this theory by the discovery that a letter can be identified more accurately when it occurs in a word than when it is presented alone. For example, if the word READ or the letter E is presented very briefly, the E is more likely to be identified correctly in the word. This piece of very basic science appeared to give tantalizing clues undermining the discrete-stage theory, and became the focus of subsequent experimental studies throughout the 1970's. Interest immediately centered on the possibility that somehow recognition that the letters form a word could inform the process of identifying the letters. Yet this possibility seemed logically incoherent. The evidence pointed to the possibility that the identity of the word was accessed via identification of the letters, and yet identification of the letters still depended on whether the letters formed a word.

The puzzle was solved by Jay McClelland and David Rumelhart through the development of an explicit model (implemented in a computer program) called the *interactive activation model*, in which the process of letter and word identification takes place via the propagation of graded (continuous-valued) activation signals among units standing for possible features, letters, and words. Feature units tend to excite units for letters that contain the feature, and letter units tend to excite units for words that contain the letter. Also, word units tend to excite units for letters contained in the word. Activation builds up gradually over time, and propagates as it begins to build from the letter level to the word level, whence it may propagate back to speed activation of units at the letter level. Because of this, the excitation of a letter unit comes to reflect both the influences arising from the features directly relevant to the letter itself, and the influences arising from the surrounding letters, by way of word-level activations.

These ideas opened up new ways of thinking about all aspects of human cognition, perception, and action, covering visual perception, language, memory, acquisition and retrieval of factual knowledge, and the control of cognition by goals, plans, and intentions. Correspondingly, they opened up new ways of thinking about a variety of disorders, two of which we mention briefly below.

1. In schizophrenia, a debilitating mental illness falling in the purview of the National Institute of Mental Health, patients often fail to produce contextually appropriate behaviors instead making the most frequent response to a situation even when it is not appropriate. This occurs for example if a schizophrenic is asked to name the color of the ink a word such as RED is printed in. If the word is printed in blue ink, the correct response is blue; normal subjects experience some delay because of the conflict between the two alternatives but this is accentuated in schizophrenia. The magnitude of the effect varies with the severity of the condition, and has been explained by models that grew out of the interactive-activation model, in which the choice of response reflects the interplay of influences arising from brain areas involved in maintaining a representation of task goals and other brain areas involved in processing of letter and color signals. Schizophrenia is thought to involve a reduction in the degree of activation of the task-goal representation, allowing the intrinsically stronger response tendency to dominate behavior.

2. In aphasia, a condition resulting from stroke and falling in the purview of the National Institute of Deafness and Communication Disorders, patients often make errors in producing words to name objects. The pattern of errors has been a matter of some puzzlement because patients make errors that reflect distortion both of sound and of meaning. Thus, in naming a picture of a cat a patient might say 'dog' or 'hat'. Importantly, errors are most likely when there is an alternative word that is similar to the correct word in both sound and meaning, especially when the word is of relatively

higher frequency. Thus when a picture of a hog is shown the response 'dog' can become quite likely. These findings create serious problems for models based on a series of discrete stages, but are well explained by interactive-activation models that were first extended from reading to apply to speech errors seen in normal speakers, and then subsequently applied to account for the pattern of deficits seen in aphasia.

Research support from the National Institute of Mental Health has been instrumental throughout the development of the approach. Recent developments in this line of research has led to a broad theory of memory, a theory of children's development of representations, a theory of conceptual development, and a theory of decision making applied to both simple perceptual judgments and to preferential choice (e.g., choice between a luxury car and an economy car).

These basic-science investigations have gone hand-in-hand with the detailed application of the approach to addressing a wide range of disorders of cognition. Under the former mission of NIMH to support basic science research aimed broadly at understanding human mental processes, this work has flourished, as has its extension to address a range of disorders. These include schizophrenia and aphasia, mentioned above, as well as hemispatial neglect, organic amnesia, dementia associated with Alzheimer's disease and other brain diseases, and developmental abnormalities including dyslexia, developmental language impairment, and autism.

These disorders mentioned above are all being explained as a result of the successful development of single NIH supported integrative theoretical framework that seeks to elucidate the shared principles underlying all aspects of human cognition, perception, and action, and that touches on the purviews of six different NIH institutes (NIMH, NIDCD, NIA, NINDS, NICHD, and NEI). The narrowing of the mission of the NIMH places the continuation of support for this broad effort in jeopardy, our at least under unfortunate constraints: Investigations of disorders would be limited to those of specific relevance to the mission of NIMH, undercutting the breadth of phenomena on which the search for general principles would be based.

Training

This piece addresses the importance of basic behavioral science training programs, not only for the advancement of the basic science, but to train those who will be the leaders in applying that science in translational studies and direct clinical applications.

Changes in the funding policies at NIMH have a particularly negative impact on the provision of training funds for basic behavioral scientists. The roots of the problem can be traced to the structure of NIH, where institutes are centered on diseases rather than general principles and processes that influence disease onset or progression. Some examples of basic behavioral processes with implications for multiple diseases include attitude and behavioral change, adherence to behavioral regimens, social influence, information processing, and basic processes in emotion, learning, pain, and decision making. They also include theories of the nature and effects of stress and personality and of socio-cultural factors including families, institutions, and socioeconomic status.

We believe that research training addressing such issues should occur within a framework of behavioral and psychobiological theory. In the medicine there is an impetus to work from clinical insight, and to build a knowledge base empirically, but often atheoretically.

The development of theories of basic behavior processes has the advantage of integrating empirical knowledge and suggesting implications outside of our immediate focus of study. A strong knowledge base in behavioral theory and evidence allows the creation of a more sophisticated and effective science of behavior and medicine that is applicable in addressing multiple disease outcomes. Instead of recreating the wheel for each problem we address, it allows for a cumulative science with implications across problem areas.

Scientist trained in these basic science areas can enter any of a wide range of medical settings and address a broad range of medical issues drawing from a non-disease specific training. In fact, many of the most influential scientists in behavioral medicine are products of such training, and have consequently had a broad influence. Up until recently, some basic behavioral training was funded by T32s at NIMH. Now, behavioral training grants are limited to those that are specifically targeted at major psychiatric disorders.

Biographical Information

"Committee for the Exploration of Health Relevance in Basic Behavioral Science"

Biographical Information

Peter Balsam, PhD
Peter Balsam received his B.S. in psychology from the State University of New York at Stony Brook. He then earned his Ph.D. from the University of North Carolina –Greensboro in 1975 in experimental psychology. Balsam is the Samuel R. Milbank Professor of Psychology at Barnard College of Columbia University where he is a former Chair of the Psychology Department and Director of Neuroscience and Behavior Program. He has been a visiting research Professor at Yale University and the University of Hawaii. Dr. Balsam has served on numerous editorial boards and grant panels. He was elected a Fellow of the American Psychological Association, American Psychological Society, and the American Association for the Advancement of Science. He is also the past-president of the Eastern Psychological Association. Some of Balsam's lectures on Pavlovian Conditioning have been videotaped and are distributed by the Society for the Quantitative Analysis of Behavior. His research has focused on the behavioral mechanisms of learning. He has published on the mechanisms of Pavlovian conditioning, new response learning, the role of learning in behavioral development, and on how time affects learning and performance.

Mahzarin Banaji, PhD
Mahzarin Rustum Banaji was born and raised in India, in the town of Secunderabad, where she attended St. Ann's High School. Her B.A. is from Nizam College and her M.A. in Psychology from Osmania University in Hyderabad. She received her Ph.D. from Ohio State University (1986), was a postdoctoral fellow at University of Washington, and taught at Yale University from 1986 until 2001 where she was Reuben Post Halleck Professor of Psychology. In 2002 she moved to Harvard University as Richard Clarke Cabot Professor of Social Ethics in the Department of Psychology and Carol K. Pforzheimer Professor at the Radcliffe Institute for Advanced Study.

Banaji is a Fellow of the American Association for the Advancement of Science, the American Psychological Association (Divisions 1, 3, 8 and 9), and the American Psychological Society. She served as Secretary of the APS, on the Board of Scientific Affairs of the APA, and on the Executive Committee of the Society of Experimental Social Psychology. She was elected fellow of the Society for Experimental Psychologists in 2005. Banaji has served as Associate Editor of *Psychological Review* and of the *Journal of Experimental Social Psychology* and is currently Co-Editor of Essays in Social Psychology. She serves on the editorial board of several journals, among them *Psychological Science, Psychological Review, Journal of Personality and Social Psychology,* and *The DuBois Review*. Her research has been funded by the National Science Foundation, the National Institute of Mental Health, and the Third Millennium Foundation.

Banaji was Director of Undergraduate Studies at Yale for several years, chaired APS's Task force on Dissemination of Psychological Science, and served on APA's Committee on the Conduct of Internet Research. Among her awards, she has received Yale's Lex Hixon Prize for Teaching Excellence, a James McKeen Cattell Fund Award, and fellowships from the Guggenheim Foundation and the Rockefeller Foundation. In 2000, her work with R. Bhaskar received the Gordon Allport Prize for Intergroup Relations. With Anthony Greenwald and Brian Nosek, she maintains an educational website that has accumulated over 3 million completed tasks measuring automatic attitudes and beliefs involving self, other individuals, and social groups. It can be reached at www.implicit.harvard.edu, and details of the research may be found at www.people.fas.harvard.edu/~banaji

Banaji is an experimental psychologist who studies human thinking and feeling as it unfolds in social context. Her focus is primarily on mental systems that operate in implicit or unconscious mode and its implications for mental health. In particular, she is interested in the unconscious nature of assessments of self and other humans that reflect feelings and knowledge (often unintended) about their social group membership (e.g., age, race/ethnicity, gender, class). From such study of attitudes and beliefs of adults and children, she asks about the social consequences of unintended thought and feeling. Her work relies on cognitive/affective behavioral measures and neuroimaging (fMRI) with which she explores the implications of her work for theories of individual responsibility and social justice.

Sheldon Cohen, PhD
Dr. Sheldon Cohen is the Robert E. Doherty Professor of Psychology at Carnegie Mellon University. Dr. Cohen is a member of the National Academy of Science's Institute of Medicine. He is the recipient of the American Psychological Association's Distinguished Scientific Contribution Award, the American Psychological Society's James McKeen Cattell Fellow Award for outstanding lifetime contributions to research in applied psychology, the American Psychological Association's Award for Outstanding Contributions to Health Psychology, and the National Institute of Mental Health's Research Scientist Development, and Senior Scientist Awards. He was an American Psychological Association Distinguished Lecturer, and a British Psychological Association Senior Fellow Lecturer.

Dr. Cohen's work focuses on the roles of stress, affect, and social support systems in health and well-being. He has published pioneering theoretical and empirical work on the effects of aircraft noise on health and development of school children, and on the roles of stress and social networks in physical and mental health. Over the last 20 years he has studied the effects of psychological stress, social support, and social status on immunity and susceptibility to infectious disease. He is also involved in studies of the effects of psychosocial factors on the onset and progression of asthma, and on the effectiveness of social support interventions in facilitating psychological adjustment and disease progression in women with breast cancer. His current work focuses on how early childhood experiences influence immunity and host resistance to infectious disease.

Daniel Kahneman, PhD
Daniel Kahneman is Eugene Higgins Professor of Psychology and Professor of Public Affairs at the Woodrow Wilson School, Princeton University. His research has ranged widely. He has studied basic processes of vision, including masking and apparent motion, pupillary measures of effort, and the role of grouping factors in visual attention. In collaboration with Amos Tversky he initiated the study of judgmental heuristics and developed prospect theory and a treatment of framing effects in decision making. He has also studied fairness in economic decision making, the valuation of public goods and the psychology of juries. His main current interest is in hedonic psychology and the development of measures of well-being that could serve as indicators of human welfare for purposes of policy evaluation. Kahneman has written one book, edited three others, and published over 120 articles. He is the recipient of several honors, including the Nobel Prize in Economic Sciences 2002, 2002 University of Louisville Grawemeyer Award for Psychology, Career Achievement Award, Society for Medical Decision Making, 2002, Distinguished Scientific Contribution Award of the American Psychological Association, and the Hilgard Award for Career Contribution to General Psychology, and an Honorary doctorate degrees from the University of Pennsylvania, University of Trento, Ben-Gurion University, New York University. He is a member of the American Academy of Arts and Sciences.

Jennifer Lerner, PhD
Dr. Jennifer Lerner is the Estella Loomis McCandless Associate Professor in the Department of Social and Decision Sciences at Carnegie Mellon University. Lerner directs the Emotion and Decision Making Laboratory at Carnegie Mellon. Drawing on psychology, economics, and neuroscience, the lab develops interdisciplinary approaches to the study of emotional influences on human judgment and decision-making.

Professor Lerner has received several awards for her research, including a junior endowed chair from Carnegie Mellon and the 2004 Presidential Early Career Award for Scientists and Engineers (PECASE). The National Science Foundation and the White House award the PECASE as "the highest national honor for investigators in the early stages of promising research careers."

Professor Lerner's research has appeared not only in scientific journals but also in major media outlets, including *The Wall Street Journal*, *The Washington Post*, *USA Today*, and National Public Radio." Funding for her research comes primarily from the National Science Foundation and the National Institute of Mental Health.

Lerner completed a Ph.D. (1998) at the University of California at Berkeley, a B.A. at the University of Michigan Honors College, and a postdoctoral fellowship at UCLA (awarded by the National Institute of Mental Health).

James L. McClelland, PhD
Jay McClelland received his Ph.D. in Cognitive Psychology from the University of Pennsylvania in 1975. He served on the faculty of the University of California, San Diego, before moving to Carnegie Mellon in 1984. He is a founding Co-Director of the Center for the Neural Basis of Cognition, a joint project of Carnegie Mellon and the University of Pittsburgh. He is currently Walter Van Dyke Bingham Professor of Psychology and Cognitive Neuroscience, with joint appointments in Computer Science and Biological Sciences at Carnegie Mellon and in the Department of Neuroscience and the Center for Neuroscience at the University of Pittsburgh.

Over his 30 year career, McClelland has contributed to both the experimental and theoretical literatures in a number of areas, most notably in the application of connectionist/parallel distributed processing models to problems in perception, cognitive development, language learning, and the neurobiology of memory. He was a co-founder with David E. Rumelhart of the Parallel Distributed Processing research group, and together with Rumelhart he led the effort leading to the publication in 1986 of the two-volume book, *Parallel Distributed Processing*, in which the parallel distributed processing framework was laid out and applied to a wide range of topics in cognitive psychology and cognitive neuroscience. McClelland and Rumelhart jointly received the 1993 Howard Crosby Warren Medal from the Society of Experimental Psychologists, the 1996 Distinguished Scientific Contribution Award from the American Psychological Association, the 2001 Grawemeyer Prize in Psychology, and the 2002 IEEE Neural Networks Pioneer Award for their pioneering work in this area.

McClelland is a University Professor at Carnegie Mellon and a member of the National Academy of Sciences. He has served as Senior Editor of *Cognitive Science*, as President of the Cognitive Science Society, and as a member of the National Advisory Mental Health Council. Other honors include the APS William James Fellow Award for lifetime contributions to the basic science of psychology. He currently teaches cognitive neuroscience and conducts research on learning, memory, conceptual development, spoken language, and semantic cognition.