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Commentary on Psychology

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The field of Psychology, which is the study of the mind, is one of extraordinary breadth. As a field of study, Psychology must encompass not only a description of the many and various aspects of everything minds do, but of increasing interest in the 20th Century, the mechanisms by which specific brain processes develop and maintain the various and numerous components and functions of the mind. A primary shift in the 20th Century was for Psychology to move beyond its initial focus on describing what minds do, with a major focus on disturbed or abnormal behavior, to an in depth, scientific study of how, and even why, the various components and functions of the mind work as they do, specifically in terms of brain function. Put simply, Psychology in the 20th Century became a science.

Central to the scientific study of Psychology has been the need to encompass and explain the vast individual differences that comprise the broad spectrum of mental and neurological functioning, from what is considered within the range of normal to what is classified or diagnosed as abnormal. Similarly, it has been necessary to account for individual differences in the rate and order of acquisition of a myriad of developmental processes, as well as for factors effecting creativity and originality throughout the life span.

Because of the constraints necessarily imposed by the scientific method, coupled with the magnitude of encompassing the vast individual differences across the broad spectrum incorporated within the field of Psychology, it is perhaps not surprising that 20th Century Psychology has been characterized by fractionation.

The 20th Century saw the mature fields of physical sciences related to the brain, (anatomy, physiology, chemistry, biology, pharmacology and genetics) merge to form the united field of modern-day Neuroscience. During the same period of time, however, the field of Psychology, that began the 20th Century as a fledgling science, has become increasingly fractionated into distinctly different disciplines. Throughout much of the 20th Century, university Psychology departments encompassed training in social, clinical, physiological, applied, neuropsychological, educational, occupational, organizational and cognitive aspects of Psychology. However, as we close the 20th Century, many Psychology faculties have now divided into separate departments and programs, particularly separating clinical psychology from experimental and cognitive sciences. Today, clinical and scientific approaches to Psychology are often taught in separate departments, have separate curricula, requirements, professional societies and journals and, perhaps most importantly, professional identities.

Along with the fractionation of the field of Psychology into separate sub-field entities, 20th Century Psychology, as a scientific endeavor has been characterized and driven by dichotomous theories and approaches. Primary amongst these dichotomies have been those pertaining to mind vs. brain, nature vs. nurture, clinical vs. experimental and normal vs. abnormal. Other variations on these main themes, that have driven research and characterized much research discussion, argument and approach in the 20th

Century include modularity vs. mass action, experimental vs. theoretical, molecular vs. behavioral, structure vs. function, behavioral vs. cognitive, genetic vs. environmental, conscious vs. unconscious, and perhaps above all others – innate vs. learned.

It is fair to say that as we enter the 21st Century, Psychology as a unified discipline is at a crossroad – fractionated by its own internal struggles about the separateness of mind, brain, soul and society.

One exception to this fractionation of Psychology has been the field of Neuropsychology. Neuropsychology is the study and treatment of patients with brain abnormalities, either developmental or acquired. By its very nature, Neuropsychology incorporates most other branches of 20th Century Psychology – clinical, physiological, social, developmental, occupational, experimental and cognitive. Indeed, the scientific study of Neuropsychology strives to find direct links (rather than dichotomies) between brain structure and function; between the mind and the brain. In addition to linking many of the domains of clinical and experimental Psychology, Neuropsychology also forms a natural bridge between the fields of Psychology and Neuroscience, incorporating both clinical and basic sciences.

As the 20th Century comes to a close and we look forward to the 21st Century we see the emergence out of the field of Neuropsychology the powerful new field of Cognitive Neuroscience – sitting squarely between traditional Psychology and Neuroscience. I have characterized this new field of Cognitive Neuroscience as "powerful" because it has the potential not only to capitalize on, but also to exponentially build upon, all of the remarkable achievements of the 20th Century in both Psychology and Neuroscience, ultimately leading to the formation of an amalgamated, expanded field

of Behavioral and Neural sciences, which will play a major role in scientific advances in the 21st Century. During the 21st Century, this new, united field of Behavioral and Neural Sciences will go a long way toward breaking down the major dichotomies of the 20th Century, linking together mind with brain, genetics with environment, structure with function, innateness with learning.

Technological advances will play an essential role in the success of this new field of Behavioral and Neural Sciences. The ability to image the structure and function of the human brain *in vivo* has already begun to provide new insights linking mind and brain. However, current neuroimaging methodologies are constrained in both their temporal and spatial sensitivity. They are also constrained in their applicability to the study of on line neural processing in real time, particularly longitudinally over time in the developing brain. Progress in linking the advantages of current neuroimaging technologies, such as electrophysiological event related potentials (ERPs), metabolic functional imaging such as fast magnetic resonance imaging (fMRI) and positron emission tomography (PET), neurochemical spectroscopy (SPECT) and magnetoencephalography (MEG) will be eagerly awaited. At the same time, developing methods and analytical procedures for reducing or eliminating the problems of head movement, eye blinks, muscle movement and noise, and for obtaining real time, single trial data, will greatly increase the applicability of these and as yet undiscovered new brain imaging technologies. These advances will be of importance particularly to the study of individual differences in normal and abnormal brain development, for assessing the efficacy of neural interventions, and for linking physiological and mental functions, specifically at a systems level.

Enhanced computational capacities and models will also play a significant role in the new field of Behavioral and Neural Sciences. Dr. Rita Colwell, the current Director of the National Science Foundation, recently called for increased investment in basic computing and communications research. She pointed out that whereas science used to be composed of two endeavors, theory and experiment, it now has a growing third component: computer simulation, which has the potential to link the other two. As behavioral and neural scientific questions become more interdisciplinary, they also become more complex and interconnected. Enhanced computational capacities and models will be needed to grapple with these increasingly complex adaptive systems.

Finally, Internet technologies also have the potential to play a significant role in the 21st Century, advancing links between the Behavioral and Neural Sciences. The Internet will facilitate communication between scientists across fields and domains, while providing for unprecedented, rapid dissemination of cross-disciplinary scientific information around the world. The Internet will also allow a new form and capacity of data collection in experimental studies of individual differences to be collected and analyzed on-line. Studies ranging from the development of normative data of specific psychophysical, cognitive or mental functions across ages, to the evaluation of the effects of brain damage in rare patient populations, will likely be greatly enhanced by Internet data collection on an unprecedented scale, directed by collaborative International consortia of multidisciplinary scientists. Similarly, advances in teaching, training and remediation methodologies will also be able to be disseminated widely over the Internet to individuals across wide geographic, economic, and demographic areas, while maintaining quality assurance and collecting uniform evidence of efficacy. Enhanced

computational capacities, algorithms and models, coupled with advances in Internet technologies, will likely transform our capacity to study the multi-dimensional, complex adapting systems of the human brain in the 21st Century.

The major beneficiary of the united new field of Behavioral and Neural Sciences in the 21st Century will be the public. Few families are not at some point individually and personally effected by a behavioral/neural problem, resulting in sub-optimal brain functioning of one or more of its family members. We need only think about the massive impact of developmental neural cognitive disabilities such as mental retardation, autism, attention deficit disorders, language learning disabilities such as dyslexia, or emotional and mental disturbances such as depression, schizophrenia, anxiety disorders to understand the magnitude of individuals effected by Behavioral and Neural problems. We can add to these pervasive human maladies others such as stroke, addictions, neuro-muscular motor disorders which include Parkinson's disease, muscular dystrophy, multiple sclerosis, cerebral palsy and dystonias, or neuro-degenerative diseases such as Huntinton's or Alzheimer's disease, and other forms of senile dementia, to begin to understand the magnitude of the impact of mental and neurological problems that can occur across the lifespan. Sub-optimal behavioral/neural functioning takes an enormous toll at all levels of society, putting enormous strain not only on individual families, but also on our public education system, judiciary system, social services, medical care system and businesses.

The Librarian of Congress, James H. Billington, has charged each of the participants of this Bicentennial Symposium on Frontiers of the Mind in the 21st Century to focus broadly on a) the highlights of our field in the 20th Century, b) what our field is

likely to accomplish in the 21st Century on the basis of what has already been done in the 20th Century and finally c) where, personally, each of us would look for an altogether new breakthrough in our field. In closing my commentary on the field of Psychology, I will summarize my position on each of these questions, with the caveat that few are given the foresight to predict correctly the future.

It is my view that the greatest advance in the field of Psychology in the 20th Century has been the transformation of the study of the mind into a field of science. This has led to the fractionation of this vast field into a series of sub-fields, in an attempt to study its component parts by means of the scientific method. It has also led to the development of dichotomous thinking, to a great extent, as a means of grappling with the complexity of the main issues that have driven and dominated the research agenda in Psychological science throughout the 20th Century.

Based on the foundation of accomplishments in the 20th Century, it is likely that many of the basic dichotomies that have dominated the field of psychology, particularly those pertaining to questions of mind vs. brain, nature vs. nurture, and clinical vs. experimental (scientific) will become the focus of unification across the fields of Psychology, Neuroscience and Genetics in the 21st Century. With a growing understanding of the mind as a complex, ever-adapting, genetic/neural/behavioral/social system, new technological advances will allow us to move toward an increasingly integrative perspective in the 21st Century.

Personally, I would look for new breakthroughs to emerge from our ability to capitalize on new discoveries resulting from integrating behavioral and neural science research. Specifically, I expect advances will emerge from recognizing that the central

nervous system is plastic (adapting) throughout the life span, and that it is directly modified and modifiable through environmental input. I expect the greatest advance of all to emerge from bringing these scientific discoveries to bear on developing a new generation of educational and rehabilitative methods for enhancing human potential. Just as Psychopharmacology and genetics have changed and dominated the way we have thought about and treated the great maladies of the human mind and brain in the 20th Century, I personally will look for altogether new breakthroughs in the development of technology based "cogniceuticals" to revolutionize both current educational approaches as well as the clinical treatment of mental and neurological disorders, in the 21st Century. By combining advances from behavioral, genetic and neural sciences research, with the power of new technologies, we should be able to optimize human higher cortical functioning on a massive scale. To do so, however, we must work together to break down existing barriers across fields and professions, as well as to develop more optimal methods for more rapidly linking scientific discoveries with their public utilization.

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