

## THE UNIQUE AND GROWING INFLUENCE OF THE NEUROSCIENCES ON THE DEVELOPMENT OF OUR CULTURE

ROBERT J. WHITE

If we are to define and refine the cultural values of science in relation to human existence, we must continue to gain a greater understanding of the human mind and the brain. In the process, we must pause and once again ask ourselves the deep fundamental question: Who are we? In addressing this concept, we must take up the issue of: What are we? The classical Christian response to these questions is, of course, 'You are composed of body and soul and made in the image and likeness of God' in a Thomistic sense, primary matter and substantial form.

Perhaps, in an attempt to analyze this state we might begin with the physical body. Obviously, we can all describe the visual appearance of a person utilizing our senses but since we cannot physically observe the human soul the problem immediately arises as to where it is located, for example, within or outside the body or diffused throughout the substance of the entire soma.

What one would like to emphasize in the brief presentation above is that in the framework of our culture and its evolution and future to come, a single bodily entity, the human brain, has been totally responsible for all of the accomplishments of mankind since time immemorial. What we are saying is quite overwhelming for we are stating, categorically, that a living substance weighing no more than 3.5 pounds has discovered, constructed and learned all we know about the universe and ourselves. It is, then, the repository of all human knowledge gained to date and is completely responsible for all activities, be they good, bad or indifferent, of all generations in the past, the present and the future. Many medical scientists believe that

the body itself represents nothing more than a power pack whose primary responsibility is to keep the brain viable. The Central Nervous System's (CNS) other anatomical element, the spinal cord, is equipped with peripheral nerves as is the brain with its cranial nerves to conduct information to this organ and to convey instructions from it to all systems of the body. Thus, this cellular structure must provide for the assimilation and processing of all this information from these sensory sources that often arrives simultaneously requiring decision-making within milli-seconds.

One must apologize for this rather simplistic discussion of the human nervous system that enjoys such cellular and molecular complexity and architectural uniqueness. Think for a moment, of a musician playing the piano and singing an aria from some classical repertoire. Just try to imagine how many areas of both cerebral hemispheres must be involved to carry out this performance. In spite of all the research conducted on music, and the brain, we still have very little understanding as to how all of these functions fit so beautifully together. Yes, the human brain is the most complex, most incredible 'object' in the entire universe as we know it. Many would be inclined to argue these extraordinary properties that brain tissue provides are anchored to its biochemical and physiological base, but still more appropriately thought to be more 'correctly' identified with the mind.

Thus, is the mind just a sum of all the abilities and functions displayed by the physical structure – the brain? Or, is it a special form that inherits the brain but is not an organic part of it? All of these relationships are, obviously, important if not critical to our discussion of science and culture, for in the final analysis it is the mind/brain consortium that produces, amplifies, and modifies our culture in all of its dimensions.

What is being emphasized in this presentation is the simple axiom that whatever culture is, or becomes, in all of its elements, the human brain/mind is responsible. Thus, our appreciation of the universe in terms of space, time, and energy, is extremely limited and, in time, even our present concepts may be found to be totally incorrect. What is fascinating, is that in spite of all the scientific efforts of such men as Fr. George Coyne, with all their incredible telescopic equipment and computers, in the final analysis, they (the cosmologists), as human beings, must gather and interpret data defining what our universe really is. Once again, it is their brain/mind interface that will accomplish this awesome task.

When we examine the many factors that encompass our civilization and define our culture now, and in the future, the immediate issue arises: Who is responsible for its design and development? Obviously, we, the

world's population, are! It is imperative that we work to eliminate poverty and increase the level of education in the world. As a result, this critical responsibility and special attention must be focused on providing a scientific education for the youth of all nations. Within this educational effort, the discipline of neuroscience must be emphasized. Without the knowledge and understanding of the human brain/mind consortium, the advance of world culture and civilization could be severely compromised. As our human population moves into the future, the Earth could potentially become an inhospitable place with a severe shortage of resources such as lack of water, fuel, food and/or land for living. Thus, our evolving civilization and culture will be severely tested in the future requiring dramatic advances in many fields of science. Not only will this require important acquisitions of new knowledge, but the creation of technologies that presently do not exist if mankind is to survive well into the future. With birthrates in third world countries continuing to increase (although their overall populations are now being modified by the AIDS infection epidemic) and starvation, as well as the continuing overuse of the Earth's resources by the advanced countries, this will bring about serious limitations and will require major alterations in how we will live in the future. As a consequence, our civilization, and its associated culture, will demand overwhelming changes in all aspects of life to accommodate the evolutionary nature of our world as well as the universe. As has been emphasized over and over again, the necessary achievements required to sustain the viability of humanity are obviously through scientific advancement, which involves the intense participation of the human mind/brain.

While we have stated this crucial concept before, it is simply not easy to convince even the scientists themselves that this integrated relationship between the physical brain and mind must, in the final analysis, be at the very center of human existence as we know it. Everything we know, everything we do, results from this extraordinary relationship. While all scientific endeavors will continue to be essential to the formation of our culture in all of its dimensions, it remains for the discipline of neuroscientists to discover the origins of the 'bonding' of mind and brain and, in the process, be able to characterize the unique functions of this organ. Some would argue that in spite of outstanding research with subhuman primate models by Professor Singer, and others, our knowledge of the brain and mind is still severely limited and fragmentary at best. Such seemingly simple questions as: What is consciousness? What is memory? How and where is cognitive activity taking place? These are just a few of the fascinating capa-

bilities of the human brain/mind. Yes, this is the most intricate and foreboding entity in the entire universe. Within its cellular/fiber architecture, embedded in a watery gel, these absolutely unique properties exist and perform. Yes, it is in this miniature organic edifice that all these activities are taking place, often simultaneously. While many of these attributes of the human brain are thought to be unique unto themselves, the basic neurochemistry and physiology of the human brain appear to be essentially similar to what has been documented in the mammalian brain of lower animals. This is also true of the fundamental cellular structure and arrangement. However, the size and weight of man's brain favors the human. Also, the number of brain cells (neurons) and their connections (axons and dendrites) are markedly increased in the human brain represented by tissue impaction as seen on microscopic examination of CNS tissue histology. Thus, with this incredible biological mechanism man constructs and destructs our civilization and our culture.

Yes, this simple thesis dramatically demonstrates the importance of neuroscience, the scientific specialty charged with studying and explaining the human nervous system. In the process, we must charge it with the responsibility of not only discovering the loci of emotions, the regions for cognitive performance (including storage of intelligence and decision-making) and, of course, memory in all of its dimensions. This list of functions of cerebral tissue represents only a small number of activities that this organ is responsible for. One might ask at this point: Is there a cellular center for good and evil thinking, free will, love and hate, and sin? If such physical representations for these activities do not exist in the human brain, then, how do we appreciate and define beauty as supplied by a visual and auditory input? In other words, how and where do our cerebral hemispheres decide a piece of art, or music, is beautiful? There is literally no aspect of our culture (in which there is always an advancing and changing concept with multiple facets) that is not directly and totally produced and influenced by the human brain. Thus, it is obvious how important neuroscience, in the process of studying the brain, is to our developing culture.

Excitingly, there have been significant achievements in recent years in an attempt to explain these incredible functions of man's central nervous system. Much of this advancement is related to the introduction of highly sophisticated instruments that actually permit the neuroscientist to observe and collate information during directed activities in the human cerebrum.

These specialized imaging machines known as Positron Emission Tomography (PET) scans, and functional Magnetic Resonance Imaging

(fMRI) scans, generally provide recordings of changes in regional cerebral blood flow as well as measurements of localized metabolic activity utilizing radioactive labeled chemicals such as molecular O<sub>2</sub> and glucose that are rapidly utilized by cerebral tissue during metabolic performance. While these instruments have extremely important functions in neuromedicine, they continue to represent one of the most critical advancements in neurotechnology for the investigation of the human brain in terms of locating the basic cellular areas responsible for various functions. For example, the location of such function such as movement, audiation and vision have been anatomically defined for at least a century. Now, with brain imaging studies the exact locations, often multiple, for these functions can be precisely documented in the cerebral cortex. In a clinical sense, brain imaging can now diagnose neurodegenerative conditions as well as malignant changes on the basis of their energy status. Evidence is also accumulating that psychiatric disorders such as schizophrenia and depression, even violent behavior, present with lower metabolic activity in certain areas of the brain. If you can identify a region in the human brain where there are metabolic alterations occurring, for example associated with violent behavior, then, with further refinements of this biotechnology, we will be able to find the anatomical areas in the brain in which the refinements of human performance (discussed previously) will be documented. Hopefully, as this neuroimaging technology carries forward, ancillary studies in cognitive psychology, neurophysiology, neurochemistry, and computer simulation will assist in understanding how the physical areas of this organ actually perform. Having this neuro-information available should, at long last, assist mankind in accepting how humanity structures the elements of our society, and how it forms and defines our culture bringing it literally into existence. All this knowledge of the brain carries an additional factor in terms of effecting our culture and civilization itself; which, in final analysis, could be a supremely crucial factor both in a positive and negative way. We are discussing here an entirely new field, that of neuroaugmentation. At present, this is best presented in two ways: First, the neuropharmacology effect on the neurochemical format of the brain that will result in subtle or even dramatic changes in cerebral performance. In time, significant improvements in memory, cognition and intelligence will be produced as a result of brain/mind functional chemical enhancements. Second, through the intervention of brain surgery. Obviously, the science of neuropharmacology has already provided hundreds of mood altering drugs but, in time, with further research the surgi-

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cal-neurological area will become very important. Its beginning can be traced to the era of tissue ablative operations for pain and frontal lobotomies for intractable psychiatric disease. Now, we are rapidly reaching the time when surgery/electronic control of brain function will be possible.

Already such diseases as Parkinsonism have their neurological symptoms decrease through a stimulation procedure via precise stereotaxically placed electrode systems in the depth of the brain. There is growing evidence that with further design of this already sophisticated equipment, significant mental control of an individual would be possible. Thus, we must be prepared to harness the mega contributions from neuroscience research for the good of our evolving culture. At the same time, we must be extremely careful about permitting any chemical or surgical biotechnologies to alter the fundamental nature of man. Neuroscience, as all sciences, must continue to contribute to, as well as help shape, our culture, but always in a positive and moral way.

## DISCUSSION ON THE PAPER BY WHITE

PAVAN: I do agree entirely with the value and purpose of the brain, but how does the brain operate in relation to culture? What are the mechanisms, the main mechanisms by which culture is made? Could I say that this is language, or are there other more important factors?

WHITE: Well, the difficulty is that in so many ways we have a great understanding of how the brain functions physically, but even with the superb presentation of Professor Singer today, I would say that much of what we attempt to understand is still very difficult. Although it may be true in the range of subhuman primates, when we ask how culture is developed and conceived, as I said in my paper, we know that the brain is the organ in which these tasks are performed, but how it works, how it assembles the facts, and how they may change or modify, I think that a great deal of that activity is still not appreciated. It can be appreciated, but just as we saw, we're talking about location, it doesn't tell us how we do it. For example, one thing we do not know is just exactly what happens if, for example, you want to raise your arm. Where does that command come from? Why was that done? Well, I think it's the same way when you are shaping, augmenting and changing what we call culture in all of its aspects: we don't know where it's done in the brain yet.

CABIBBO: Well, if I may say something as a physicist, it might be that the difference between a human and a chimpanzee is only a difference of quantity. There are many examples in physics where a small difference in quantity makes a fantastic difference in quality. Well, just to make one example, the atomic bomb, you need a certain critical mass. If you have less than that, you just have an inert piece of metal, if you have more it explodes. Another example is given by phase transitions: at a certain temperature there is agitation of atoms; if you heat water at 99 Celsius it is water, if it is at 100.0001 Celsius it becomes vapour. So, it's clear that there is a phase transition, that

there's a huge difference between man with his capacity for communication, for formal thought, for storing in a communal database, I mean, because it's true that the brain has notions of a science, but there is not a single brain which knows everything, each brain contains a little bit, it is a community of science and writing, etc., which makes a big difference, and it might be that at least certain people like you or like other scientists of the brain will tell us whether there is a qualitative difference between the human brain and other brains, I don't know, different organisations etc., but even if there is no such difference in organisation maybe a small, relatively small difference in quantity is what is needed to make this jump. You can see that animals are very close to communicating. People who have dogs or cats claim they communicate with their pets. Obviously the communication is very small. At a certain point you start a chain reaction and culture begins.

WHITE: A chain reaction, yes. But the simple thing, as I mentioned, is obviously that the size of the brain is in favour of man, and yet there are larger brains, some of the larger animals do have brains that weigh more, but it's the impaction, it's the number of neurons and the number of cells, connections, and synaptic relationships that again favour the human brain. The fascinating thing though, Professor, is that the same chemical reactions, the same histology, the appearance of the brain under the microscope, the same electrical phenomena that we see and we measure, there's nothing between these features in the human brain and what we would see in a Rhesus monkey's brain, and yet, as you point out, the difference between performance, understanding and accomplishment is overwhelming. Like Professor Singer, I've spent years working with monkeys, and I can tell you they are incredible creatures, but I haven't seen any of them build a St. Peter's yet! I went to a conference recently in America where they were trying to put together a group of lawyers who support legal rights for subhuman primates and remove them as properties under the law and they would become persons. One of the lawyers who were opposing this, stood up and said, 'Well, I don't see any of them here in the audience that are asking to have a lawyer.' But you are right: the similarities are absolutely fascinating. On the other hand, the brain is such an incredible organ, yet how can you arrest the circulation of the human brain for an hour at a very low temperature and have it be rewarmed and retain the same intellectual capabilities and personality? After all, we've stressed the fact that it doesn't have redundancy, which it does have, incidentally. It is just incredible; we have much to learn.