THE CREATIVE BRAIN / THE CREATIVE MIND

by Andrew B. Newberg and Eugene G. d'Aquili

Abstract. In the past few decades, neuroscience research has greatly expanded our understanding of how the human brain functions. In particular, we have begun to explore the basis of emotions, intelligence, and creativity. These brain functions also have been applied to various aspects of behavior, thought, and experience. We have also begun to develop an understanding of how the brain and mind work during aesthetic and religious experiences. Studies on these topics have included neuropsychological tests, physiological measures, and brain imaging. These different techniques have enabled us to open up a window into the brain. It is by understanding the functioning of the creative brain that we begin to understand the concept of the creative mind. It is through the use of emotions and other higher cognitive functions that the brain and mind can create ideas, music, literature, and ultimately our entire repertoire of behaviors. How these different creative abilities are derived can also be traced to various parts of the brain and how they function. Modern neuroscience allows us to begin to understand the creative aspect of the brain and mind and perhaps can take us one step further toward understanding the most profound types of aesthetic and religious experiences.

Keywords: aesthetics; brain; creativity; neurophysiology; religion.

Two monks were arguing about the temple flag waving in the wind. One said, "The flag moves." The other said, "The wind moves." They argued back and forth but could not agree. Hui Neng, the Sixth Patriarch, said, "Gentlemen! It is

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[*Zygon*, vol. 35, no. 1 (March 2000).]
 ISSN 0591-2385

not the flag that moves, it is not the wind that moves, it is your mind that moves." The two monks were struck with awe! (Schiller 1994, 332)

This Zen Koan describes the essence of the 1998 Star Island Conference. It was the purpose of this conference to consider how the mind and brain work to create different aesthetic and religious experiences. In order to do this, we must study how the brain and mind work in general to create the experiences that we have. We can then apply this knowledge to aesthetic and religious experiences.

To begin with, it is important to distinguish what is meant by *brain* and what is meant by *mind,* since these terms are often used rather loosely. Perhaps the easiest way to understand the relationship between the mind and the brain is to regard the brain as the structure that performs all of the functions and the mind as the product of these functions. Thus, the mind and brain may be considered two ways of looking at the same thing. The brain refers more to the structural components, and the mind refers more to the functional components.

In this paper we will look at how the brain works and how it creates for us our experience of the external world in general and of aesthetic experiences in particular. We will also consider some of the state-of-the-art technologies that are available today to look into what is going on in the mind when we have different kinds of experiences. We will describe some of the studies performed at the University of Pennsylvania and other places that have examined how changes in the brain are associated with different experiences.

An important point to make at the beginning is that the brain is always creating. All the nerve cells and nerve connections change with every new experience. And each different experience that we have is something a little new. But when we take imaging studies of the brain and look at the structure of the brain, it does not move very much, even though it is actually doing a tremendous amount of activity and is changing all the time. These changes occur on a microscopic and functional level that is best studied using functional imaging. In this paper we review some of the basic aspects of neurophysiology so that we may begin to explore the neuropsychological basis of aesthetic and religious experiences.

The Structure and Function of the Religious Brain

When considering how the brain works, we start with the human body, because this is the source of the brain's information from the external world. The brain receives input from the various sensory organs throughout the body, including those for smell, taste, hearing, seeing, and touch. Thus, the body may actually be considered an extension of the brain. We cannot conceive of the brain and body as two separate entities. They are intimately linked together. For such a linkage to occur, the brain must have some mechanism by which to communicate with the body. This includes ways of receiving information from the body and its sensory organs as well as ways of sending out information to the body in order that it may carry out our thoughts and feelings through expression in language or behavior.

One of the most important systems by which the brain communicates with the body is called the autonomic nervous system. This system helps the brain regulate various aspects of body function. There are two major components to the autonomic nervous system: the sympathetic and the parasympathetic systems (Kandel, Schwartz, and Jessell 1993). The sympathetic nervous system is the part of the brain that mediates our "fight or flight" response. It causes our heartbeat to increase, our blood pressure to rise, and our eyes to widen whenever we see something scary or frightening. We sometimes refer to the sympathetic nervous system as the "arousal system," because this is precisely what this part of the brain does—it arouses and prepares our body for whatever needs to be done.

The parasympathetic system, on the other hand, helps to maintain our baseline body functions and also to balance the arousal system. We might refer to the parasympathetic nervous system as the "quiescent system," because this is precisely the function of the parasympathetic system. It makes the body more quiescent and calm.

While the words *arousal* and *quiescent* are not the strict scientific terms, they describe these systems in a more functional manner, which may help to simplify the terminology for those without formal neuroscientific backgrounds. Throughout this paper, we use more functionally oriented names in place of scientific names in order to help the nonspecialist reader understand neurophysiological concepts.

In general, the arousal and quiescent systems tend to balance each other's activity. Thus, the more activity there is in one system, the less activity there is in the other (Gellhorn and Kiely 1973). Each system actually can suppress the activity in the other. The balance between these two systems is what provides our overall emotional approach to life. If a person is under more arousal control, then he or she might be categorized as an "uptight" person. If a person is under more quiescent control, then he or she might be categorized as "laid back."

It turns out that the interaction between the two systems is more complex than simply regulating a balance between them. If you overstimulate one of the systems to maximum activity, then the other system, rather than being suppressed, actually becomes *more* activated (Gellhorn and Kiely 1972). We refer to such an activation of the opposite system as "spillover," because it is as if there is a spillover of activity from the overstimulated system into the other system.

Given this setup of the arousal and quiescent systems, one might envision several important states arising out of their interaction with each other (d'Aquili and Newberg 1993b). The first is the hyper-quiescent state, in which the quiescent activity is extremely high (or hyper) but unopposed by the arousal system. This may occur during highly intense meditation in which a profound feeling of calmness and quiescence may be generated. The second is the hyper-arousal state, in which the arousal activity is extremely high. This state may be attained during various types of frenzied activity such as Sufi dancing or marathon running. During such activity, the arousal system may be stimulated to maximum capacity, which may be associated with the experience of a tremendous rush of energy.

The next two states involve spillover, described earlier. Thus, at the height of extreme activity in one system, there is eruption of activity in the other. One state can be described as a hyper-quiescent state with subsequent eruption of the arousal system. Within the profound, pervading sense of quiescence, the arousal system is activated. The result is that the person experiences a tremendous rush of energy during the state of intense quiescence. Such states have been described by persons in meditation when, in the midst of overwhelming calmness, they suddenly have feelings of alertness and arousal. These states have sometimes been referred to as "active bliss." There is also the hyper-arousal state with subsequent eruption of the quiescent system. In the midst of a tremendous amount of activity, a person may experience a sense of overwhelming calmness and oceanic tranquility.

The final state is when both systems are maximally activated. This would be an extremely rare event associated with very unusual circumstances. Such a state occurs primarily in extraordinarily profound states usually attained only after years of meditation practice or in certain spontaneous mystical states such as near-death experiences. In such states there is the simultaneous feeling of deep and profound quiescence with a sense of extreme alertness and awareness. Such states are often associated with beautiful visions and sounds as well as a sense of wholeness and unity.

We have described the arousal and quiescent systems as being one of the ways in which the brain communicates with the body. For this to happen, these systems, which extend throughout the body, must ultimately be connected to some structure in the brain. The first stop along the way from the autonomic nervous system is the hypothalamus. This structure is very ancient from an evolutionary perspective, and many "lower" animals have a hypothalamus that helps to regulate the autonomic nervous system. In general, even though the hypothalamus helps to regulate the autonomic nervous system, it is stimulus bound (Joseph 1990). For example, the hypothalamus reacts very quickly to a sudden stimulus, such as a car cutting us off in traffic. But as soon as that stimulus is gone, the hypothalamic activity also dissipates.

From the hypothalamus, we proceed to a group of structures that make up the limbic system. One of the primary functions of this system is the expression and regulation of our emotions and emotional responses. Thus, the limbic system helps us to apply emotional value to whatever thoughts, feelings, and experiences we may have. The first structure in the limbic system that we come to from the hypothalamus is the amygdala. The amygdala helps to modulate the activity in the hypothalamus and ultimately in the autonomic nervous system. The amygdala, in general, tends to be more arousal based (Chapman, Schroeder, and Geyer et al. 1954; Ursin and Kaada 1960). It helps us to focus on objects in our environment that are of motivational importance to us. It is also involved in more general attention, learning, and memory functions. The amygdala thus serves a number of different functions that are primarily related to our arousal activities.

A digression is necessary here. When we describe the function of a certain part of the brain, the description is based on studies that support the notion that this function is "localized" to that part. However, the brain requires all of its parts working together in order to perform its functions. Even though a particular part of the brain might be involved in a particular function, that brain part requires many others in order to fully perform that function. Thus, functions can be localized to a certain extent, but we must be careful never to make the statement that one particular part of the brain is the site for one particular function. The brain does not work that way. It is a vast array of integrated structures with integrated functions. However, it is helpful to think about certain areas as being more closely related to certain functions. This makes understanding the complex workings of the brain a bit easier.

As we proceed further into the brain, we arrive at the hippocampus. The hippocampus has primarily a quiescent function in that it helps to maintain baseline body functions via the hypothalamus and the quiescent system (Joseph 1990). The hippocampus is important in memory function and has been demonstrated to be the focus of pathological disorders that affect memory, such as Alzheimer's disease (Newberg and Alavi 1996). The hippocampus sits very close to the amygdala, and each of these structures modulates the activity of the other. This mutual control is a "theme" that runs through much of brain function, such that certain areas have a mechanism for the reciprocal regulation of their activities. The arousal and quiescent systems regulate each other, and so do the amygdala and hippocampus. The amygdala and the hippocampus also regulate activity in other parts of the brain. Specifically, the amygdala tends to facilitate activity and information transfer between different brain structures, and the hippocampus tends to inhibit activity and information transfer.

This brings us to the cerebral cortex, the large part of our brain that is involved in higher-order thinking and behavior. It is this part of the brain that separates us from other animals and has been responsible for our thought, science, culture, and art, among many other things. In general, the cortex is divided into left and right hemispheres, with similar structures on both sides (Kandel, Schwartz, and Jessell 1993). Even though the two sides appear structurally very similar, the hemispheres can have similar but different functions. For example, the left hemisphere is usually the seat of language function and for this reason is often referred to as the "dominant" hemisphere. It is this hemisphere that enables us to read, write, speak, and select specific words. The left side is responsible for all of the linguistic aspects of our language. The right hemisphere also has a language center that aids in our language abilities. However, the right hemisphere functions differently from the left in this regard. The left side helps us to select and use words, but it is the right side that interjects emotional tones and inflections into our language. The right hemisphere allows us to hear the emotional aspect of language. Thus, the left hemisphere helps us with *what* is said, and the right hemisphere helps us with *how* it is said. People who have had strokes in the right hemisphere will often have difficulty recognizing when other people are angry or happy based on the emotional inflections in their speech. This further illustrates how the right and left hemispheres function in conjunction with each other and how similar structures in different hemispheres function slightly differently.

The two hemispheres are able to communicate with each other through a series of connecting fibers called the corpus callosum, the anterior commissure, and the posterior commissure. An interesting finding regarding communication between the hemispheres is derived from so-called split brain experiments (Gazzaniga and LeDoux 1978; Joseph 1988). These experiments looked at the effects on patients of surgery in which the connecting fibers between the hemispheres were cut. This type of operation was usually performed in patients with severe seizure disorders who did not respond to medical therapy. Cutting the fibers prevented the seizure activity from spreading from one hemisphere to the other. When these patients were studied after the surgery, some peculiar findings were obtained. For example, when a picture of a hammer was presented to only the left hemisphere (by letting only part of the visual field see it), and the subjects were asked what they saw, they said, "I see a hammer." However, when that picture was presented to the right hemisphere, the patients were not able to tell what they saw, but they were able to draw it. Such studies have helped us to learn a great deal about how the two brain hemispheres communicate and function.

With regard to the different parts of the cerebral cortex, among the most important structures related to overall functioning and to aesthetic and religious experiences in particular are the association areas. These areas take input from many other parts of the brain as well as from our sensory organs and put them together to help produce an integrated understanding of ourselves and of the world around us. They are called association areas because they help associate all of the complex processing that occurs in the brain. For example, primary cortical areas receive basic input from the sensory organs. In visual processing, the primary visual area simply receives the lines, shapes, and colors from the eyes. The secondary areas process this input into rudimentary pictures, which are then sent to the tertiary association areas, which provide the fully developed picture that we can look at and recognize. Thus, the tertiary association areas are most relevant to the experience of religion and aesthetics. We have generally focused on four tertiary association areas: visual, orientation, attention, and verbal-conceptual. (These names represent the function of these structures and are not the actual scientific terms.)

The Visual Association Area. The Visual Association Area is located toward the side of the brain (in the inferior temporal lobe). The neurons, or nerve cells, in the Visual Association Area receive highly processed input from the secondary visual areas of both hemispheres (Kandel, Schwartz, and Jessell 1993). Situated within the Visual Association Area are the amygdala and the hippocampus, which, while they have functions beyond the visual system, help the visual system focus on objects and also help assign emotional value to various objects as part of the limbic system (Herzog and Van Hoesen 1976; Kling, Lloyd, and Perryman 1987). Overall, the Visual Association Area appears to be involved in the highest level of visual integration and mediates the perception and recognition of specific and particular shapes and forms.

The Orientation Association Area. The Orientation Association Area is located at the top part of the brain toward the back (the posterior superior parietal lobe). This area takes all of our sensory input and uses it to help us orient ourselves with respect to the rest of the world. Thus, the Orientation Association Area is heavily involved in the analysis and integration of higher order visual, hearing, and sensory information. It provides us with a sense of orientation within space and time (Lynch 1980).

There seems to be some difference in function between the Orientation Association Area on the right side of the brain and the Orientation Association Area on the left side (Joseph 1990). This agrees with what we described earlier about the differences between the two cerebral hemispheres. Studies have found that patients with strokes or tumors in the right Orientation Association Area have deficiencies involving depth perception and the ability to determine location, distance, spatial orientation, and object size. Further, many of these patients suffer from visual-spatial disorientation (Stark, Coslet, and Saffran 1996). While the right Orientation Association Area appears to play an important role in creating a sense of spatial coordinates and body location, the left Orientation Association Area exerts influences in regard to objects that may be directly grasped and manipulated. It seems that in the left Orientation Association Area, some neurons respond most to stimuli within grasping distance, whereas others respond most to stimuli just beyond arm's reach. It is such evidence that has caused some researchers such as Rhawn Joseph (1990) to postulate that the distinction between self and world may ultimately arise from the left Orientation Association Area's ability to judge these two categories of distance—objects within one's grasp and objects beyond. Therefore, it seems probable that the "self-other" or the "self-world" distinction that philosophers have argued about through the ages is more likely a left Orientation Association Area function that evolved from its more primitive division of space into the graspable and the non-graspable. When we consider religious and aesthetic experiences, one of the most important characteristics of such experiences involves the breakdown of the self-other distinction. Thus, the Orientation Association Area may be important in mediating this aspect of religious and aesthetic experiences.

The Attention Association Area. The Attention Association Area is situated in the most forward aspect of the brain, the prefrontal area. This area is highly involved with focusing attention, directing behavior, and performing executive functions such as balancing a checkbook or planning a schedule (Kandel, Schwartz, and Jessell 1993; Joseph 1990). It is also important in the regulation of emotions and is intimately and richly interconnected with the limbic system. The prefrontal area is profusely interconnected with all the secondary and tertiary association areas. The Attention Association Area is involved in forming conceptual thoughts via its connections with the Verbal-Conceptual Association Area and can also help in forming complicated visual images.

Also, and most important for our concerns here, the Attention Association Areas of the two hemispheres are connected to each other by fibers running across the corpus callosum (Stuss and Benson 1986). Thus, it seems certain that a part of the function of the prefrontal area is as a multimodal association area, meaning that the Attention Association Area is involved in the integration of a wide variety of sensory data (Stuss and Benson 1986). Further, this area functions in giving us a sense of "egocentric spatial organization," or how things are spatially oriented to ourselves. However, we already have considered how another area, the Orientation Association Area, is responsible for generating sensorial space itself. Hence, there must be a great deal of interconnection between the Attention Association Area and the Orientation Association Area. In fact, studies have shown this to be the case (Luria 1980; Stuss and Benson 1986).

In human beings, damage to the Attention Association Area is associated with a loss of the ability to concentrate and to plan future behavior (Pribram and McGuinness 1975). The Attention Association Area helps push all of the sensory stimulation into the background as redundant input and allows us to continue to concentrate on a particular activity. Thus, patients with injuries in the Attention Association Area not only lose the ability to plan and orient themselves to future activity but also suffer a severe deficit in carrying out complex perceptual and conceptual tasks that require concentration (Nauta 1971). These patients can also exhibit flatness of emotion and apathy and tend to have difficulty controlling their emotions (Stuss and Benson 1986). The emotional disturbances result from dysfunctional interconnections between the Attention Association Area and the limbic system. One author noted that patients with injury to the Attention Association Area seemed to display a marked indifference to events in the environment (Stuss and Benson 1986). These patients could not alter patterns of response once established, and they were usually incapable of accomplishing anything beyond their initial pattern of behavior.

Therefore, deficits in the Attention Association Area seem to result in a general loss of global sensory integrative capacity with respect to control, planning, integration, and monitoring of activity and the effects of activity. A great part of what one sees in those with injury to the Attention Association Area is a loss of will or of the capacity to form intention. If any part of the brain can be said to be the seat of the will or of intentionality, it is certainly the Attention Association Area.

The Verbal-Conceptual Association Area. The Verbal-Conceptual Association Area (located in the inferior parietal lobe) is the part of the brain that houses the language center and allows us to create and generate words about different objects (Joseph 1990; Kandel, Schwartz, and Jessell 1993). It also allows us to formulate concepts about things in the world so that we can express ourselves and think deductively about objects in the world. The Verbal-Conceptual Association Area may be the area of the greatest integration of sensory input in the brain. In a sense, it is an association area of association areas, and maintains rich interconnections with the vision, hearing, and touch association areas (Seltzer and Pandya 1978). This area also has extensive interconnections with the Attention Association Area, Visual Association Area, and other higher-order association areas throughout the neocortex. This area is responsible for the generation of abstract concepts and relating them to words. It is also involved in conceptual comparisons, the ordering of opposites, the naming of objects and categories of objects, and, in general, higher-order grammatical and logical operations. Further, this region might be very important in the development of consciousness and the expression of that consciousness through language.

Integrated Function of the Association Areas. In order to review the overall functioning of the association areas, consider their response to an object presenting itself in a person's visual field. The object stimulates the Visual Association Area to produce an image of that object. The Attention Association Area is then activated to focus the person's attention on the object. The Orientation Association Area is activated in order to provide an orientation between the person and the object, that is, where the object is in relation to the person. Both the Attention Association Area and the Orientation Association Area interact with the limbic system in order to generate an emotional response to the input. Finally, the Verbal-Conceptual Association Area is activated in order to describe the input or relate the input as part of thought. Thus, these areas function together to help the person analyze the external world.

Brain Evolution and the Cognitive Operators

When we consider aesthetic and religious experiences, we need to understand why the brain functions the way that it does. By using an evolutionary perspective, we can attempt to understand how certain functions evolved over time. This perspective implies that the brain functions in an adaptive manner such that it works for us to help us interpret the external world. By this we mean that, for the most part, whatever is "out there" needs to be perceived in the brain as it actually is. For example, if the brain did not allow us to realize that if we were to walk off a cliff there would be nothing to hold us up, then we would probably not survive for long. We would not be able to identify dangers that need to be avoided. Similarly, we would not be able to identify food, drink, or other members of our species. Thus, it intuitively makes sense that for us to survive the brain has to do a fairly accurate job of letting us know what is out there. That we are capable of perceiving causality, time, opposites, numbers, and various rhythms in the external world suggests that these actually exist in the external world. Otherwise, our brain would not be perceiving the world in an accurate and adaptive manner.

The brain has to be set up in such a way that we can perceive and understand all of these aspects of the external world. Basic brain functions are called "cognitive operators" (d'Aquili 1978). A cognitive operator is a function of either a specific brain structure or a group of brain structures working in conjunction to help us order our reality. We have identified seven cognitive operators: Holistic Operator, Reductionistic Operator, Causal Operator, Abstractive Operator, Binary Operator, Quantitative Operator, and Emotional Value Operator.

The Holistic Operator takes all of the particulars that we might experience and creates a sense of the general or holistic nature of the particulars. There are many instances, both in the sciences as well as in other academic pursuits, when an investigator will examine how the parts make up the whole. The Holistic Operator also plays an important role in everyday life, particularly in relation to aesthetics, myth, and religious experience. The Reductionistic Operator has a function that is opposite that of the Holistic Operator; it takes the whole and breaks it down into its individual parts. Science is particularly dependent on the functioning of the Reductionistic Operator. The Causal Operator helps us to observe causality and to relate one event to another in a sequential ordering. The Abstractive Operator allows us to generate abstract concepts—for example, that objects such as an elm, spruce, and oak can be categorized as "trees." The Binary Operator helps us generate a sense of opposites such that we can compare the concepts good and evil or right and wrong. This operator has particular relevance to religious and aesthetic experiences and particularly to myth formation. Religious myths tend to involve opposites that are in some form of conflict, which is then resolved through the myth (d'Aquili 1978). Likewise, many aesthetic works make use of opposites, such as light and dark or wholeness and fragmentation, which are brought together to comprise the work. When we initially observe a pair of opposites, we encounter a sense of arousal because of the incongruity between the opposites. We desire a resolution and revised understanding because of the Holistic Operator. Thus, in art, in particular, the "tense and happy indecision" (Schaible 1998) may be directly related to the functioning of the Binary Operator. These tensions enhance activity in the arousal system initially, with quiescent activity being stimulated upon resolution of the opposites within either a myth or an aesthetic work. The Quantitative Operator is involved in the generation of numbers and quantity. Thus, whenever we observe objects in the external world, we have a tendency to try to determine how many there are. Finally, the Emotional Value Operator connects the limbic system to the other operators and provides an emotional response to all of the input and thoughts that we have. This operator tells us how we feel about everything. In order to do this, the Emotional Value Operator must be able to connect to all the other operators. Clearly, this operator is crucial for the emotional response people have during aesthetic and religious experiences.

Recent studies on infants suggest that even at the age of several months, infants appear to have innate quantitative abilities despite having no knowledge of mathematics (Wynn 1990, 1992). Studies have also shown that infants have a sense of causality (Spelke, Breinlinger, Macomber, and Jacobson 1992). Such findings lend support to the notion that these operators are in place even prior to the development of language and more complex thought processes. Thus, these functions might be considered to be "preprogrammed" to a certain extent.

The Creative Mind

We can now begin to explore how we create new ideas or aesthetic works. To begin with, for creativity to occur, there must be a problem that requires solving. This may be a deductive or scientific, spiritual or aesthetic problem. Such a problem is usually articulated through the left hemisphere's language center and Abstractive Operator. This allows us to identify the problem even though we may not yet have a solution. Finding a solution to the problem likely requires interaction between the brain's two hemispheres. The right hemisphere is presented the problem in much the same manner as the left hemisphere. However, the right hemisphere does not have the same language capabilities as the left and therefore must consider the problem from a more visual-spatial perspective. This relies on memories of various problems and sensory input from the external world. The right hemisphere can then search for solutions to the original problem. When the brain finds the visual-spatial solution to the original, verbalized problem, these are matched, and an answer to the problem is transmitted to the left hemisphere, which can then describe the answer using words. An example of this creative function can be found in the discovery of the structure of benzene, a six-carbon compound with the atoms arranged in a circle. For years, no one could determine what the structure of benzene was. The scientist Friedrich Kekule, who was trying to understand the structure of benzene, was staring into a fire when the answer came to him suddenly. The flames reminded him of snakes swallowing their tails in the form of rings. The fire-snake-ring visualization was sufficiently similar to the original problem that Kekule experienced the sudden joining of the solution with the problem. Such a response has sometimes been called the "Eureka Phenomenon" and is usually accompanied by a strong emotional discharge.

In the case of artistic creativity, one might suspect that the initial problem would enter via the right hemisphere rather than the left. Thus, the original problem may begin by being more visual-spatial or emotional. Furthermore, such a problem does not find an easy verbal expression and thus may be better expressed and solved via music or art. Of course, some types of artistic creation such as poetry require both left and right hemispheric functioning. In poetry, the original problem may be more verbal or more visual, but both may be resolved ultimately through the aesthetic component of language itself. Thus, when we consider how certain aesthetic works are created, it will be beneficial to note what the individual hemispheres are doing, what specific structures are doing, and what the cognitive operators are doing during this creative activity.

Brain Imaging and the Aesthetic/Religious Experience

A number of brain imaging techniques are now available to researchers exploring which parts of the brain are working during different states. Several of the research studies have relevance to aesthetics and art, since they are related to how we experience music and other types of aesthetic works. In this section we will consider some of the brain imaging work that lends support to the view that various brain structures are involved in different religious/aesthetic experiences.

The most appropriate techniques for studying these experiences have been called functional imaging studies, because they measure various aspects of brain function including blood flow, metabolism, and neurotransmitter activity (Newberg and Alavi 1996). These techniques also allow for the measurement of these parameters in specific brain structures and hence can provide a functional map of the brain. The most common imaging techniques used today include single photon emission computed tomography (SPECT), positron emission tomography (PET), and functional magnetic resonance imaging (fMRI).

Most studies begin by taking an image of a person's brain at rest to establish a baseline and then during the performance of some type of activity. These studies are called activation studies. The activation state can be compared to the baseline state, and changes can be measured to determine how the brain's function has been altered during a particular activity or experience. For example, if a person is told to move one arm during the activation state, there will be increased activity in the region of the brain responsible for arm movement. This change in activity can be detected using one of the imaging techniques.

Several studies have been undertaken that examine various components of religious and aesthetic experiences. Our own research has utilized the results of such experiments to determine which structures might be specifically involved so that a complex model of brain function can be derived. There appears to be an aesthetic/religious continuum upon which lie various aesthetic experiences, with very profound religious and spiritual experiences at one end of the continuum (d'Aquili and Newberg 2000). We hypothesize that all of these experiences exist along the continuum and depend upon the differential functioning of various brain structures both in terms of degree and in terms of structures involved. Many aesthetic and religious experiences can be described utilizing such a model.

Imaging studies have shown that the parietal lobe (home of the Orientation Association Area) is involved in helping to rotate objects and during visual-spatial memory tasks (Berthoz 1997; Alivisatos and Petrides 1997). The Attention Association Area is involved in memory tasks and is likely related to the person's need to focus on the task that he or she is performing (Frith, Friston, and Liddle et al. 1991; Pardo, Fox, and Raichle 1991). In patients with schizophrenia, this area of the brain is not as active during visual-spatial tasks as is the same area in normal control subjects. Another interesting study involved playing music to control subjects and to highly expert musicians (Phelps, Schelbert, and Mazziotta 1983). When compared to the baseline, the control subjects activated the auditory areas as well as the association areas primarily on the right hemisphere. This is likely associated with their aesthetic experience of the music. The expert musicians tended to activate the same areas, but in the left hemisphere, suggesting that they were able to experience the music on a more analytic level, understanding the different notes, tones, and keys. Thus, people can train their brains to experience things in many different ways. Further, such a finding speaks to how we understand various aesthetic experiences.

We also have been involved in an experiment that measured changes in brain activity during Tibetan Buddhist meditation (Newberg, Alavi, Baime, and d'Aquili 1997; Newberg, Alavi, Baime, Mozley, and d'Aquili 1997). In this study, the meditation state was compared to the baseline state. The results to date have shown that during meditation a number of areas appear to be activated, including the Attention Association Area. We have hypothesized that this area should be activated, because the meditators are focusing their attention during the meditation. Furthermore, there is a relative decrease in activity in the Orientation Association Area, which we believe may be associated with the change in the meditators' sense of space and time, as well as their sense of self and other, that occurs during meditation. Such findings help support our model of brain function during aesthetic and religious experiences. But many more studies that look at various components of brain function as well as different types of experiences need to be performed. Such studies may ultimately provide more information regarding the link between mind and body. A number of studies have demonstrated the various effects of practices such as meditation on the human body. These effects include changes in heart rate, respiratory rate, blood pressure, and the immune system (Jevning, Wallace, and Beidebach 1992; Kesterson 1989; Sudsuang, Chentanez, and Veluvan 1991). By understanding the changes in brain function during meditation, we may be able to better understand how these states ultimately affect these body measures.

Conclusion

There is a story about a Zen master, Chuang-tzu, walking with his friend along a river bank.

> "How delightfully the fishes are enjoying themselves in the water!" Chuang-tzu exclaimed.
>
> "You are not a fish," his friend said. "How do you know whether or not the fishes are enjoying themselves?"
>
> "You are not me," Chuang-tzu said. "How do you know that I do not know that the fishes are enjoying themselves?" (Schiller 1994, 372)

This story makes an important point. It speaks to the uniqueness of subjective experience for each individual. It has been argued that every rainbow is unique for each person, because each observes light refracted at a slightly different angle. The same can be said of all subjective experience. Everything that we hear, see, and experience is slightly different for us compared to the experience of the person next to us. Our brain takes this unique input and generates for us a sense of the external world using its various functions and cognitive operators. If we consider such experiences from a purely neuropsychological perspective, we must conclude that what we perceive as reality is unique for each of us. We are only able to construct our reality based on the sensory input that enters our brain. How, then, can we determine if that reality is real? For example, a meditator may have a profound mystical experience and perceive that experience to be more real than baseline, everyday reality. How can he or she compare the reality of that experience to the experience of baseline reality?

Whatever we experience or feel, it is our mind and our brain that create that world for us. This brings us back to the notion that our brain and mind are always creating, because they are always creating our experience of the world. Even though we may try to confirm our interpretation of reality by cross-referencing our experience with what other people report, we must remember that those other people are also a part of our subjective experience created by our brain. Thus, we create our own reality for ourselves. Whether we perceive something as aesthetically pleasing or not, whether we understand the reality of our experiences or not, whether we are closer to what is really "out there" or not, we ultimately create our own reality. We simply do the best we can at understanding ourselves and the world as we perceive them through our creative brain and creative mind.

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