Andrew B. Newberg and Eugene G. d'Aquili

The Neuropsychology of Religious and Spiritual Experience

This paper considers the neuropsychology of religious and spiritual experiences. This requires a review of our current understanding of brain function as well as an integrated synthesis to derive a neuropsychological model of spiritual experiences. Religious and spiritual experiences are highly complex states that likely involve many brain structures including those involved in higher order processing of sensory and cognitive input as well as those involved in the elaboration of emotions and autonomic responses. Such an analysis can help elucidate the biological correlates of these experiences and provide new information regarding the function of the human brain.

Introduction

This paper will consider the neuropsychology of religious and spiritual experience. A neuropsychological analysis of these experiences serves several important purposes. It helps to elucidate the biological correlates of these experiences and provides new information regarding the function of the human brain. It provides a new understanding of how and why these experiences have had such an important role in human thought and history. And finally, it leads to an understanding of the relationship between these experiences and human health and psychological well being.

Religious and spiritual experiences such as those associated with meditation, prayer, and ritual have been described in the biomedical, psychological, anthropological, and religious literature. It has been suggested that such experiences became possible with the evolution of various structures in the brain of early primates and eventually of *Homo sapiens* (Laughlin & d'Aquili, 1974). The concatenation of 'religiogenic' brain mechanisms in *Homo sapiens* was accompanied historically by the advent of a number of religious traditions in both Eastern and Western civilizations that have continued to permeate human societies since prehistoric times. More recently, neurobiological and neuropsychological correlates of religious and spiritual experiences have begun to be postulated. By considering the current neuropsychological literature, a more complex model of the

Journal of Consciousness Studies, **7**, No. 11–12, 2000, pp. 251–66

neurophysiological events that occur during religious and spiritual experiences can be developed. Neurophysiological correlates of these experiences also can be considered in relation to the brain's interconnection with other aspects of body physiology that are modulated by the autonomic nervous system as well as the neuroendocrine system. A consideration of this relation between cognitive processes in the brain and the autonomic nervous system may yield a more complete understanding of a variety of spiritual experiences ranging from a feeling of 'awe' to intense unitary states. On the basis of these analyses, a foundation for the development of a neuropsychological model can be considered in order to guide future studies in the neurobiology of religious and spiritual experiences. In addition, the use of state-of-the-art brain imaging techniques such as functional magnetic resonance imaging (fMRI), positron emission tomography (PET), and single photon emission computed tomography (SPECT) have begun to be utilized, in addition to traditional electroencephalography (EEG), to investigate brain function in general and religious and spiritual experiences in particular (Newberg & Alavi, 1996; Newberg *et al.*, 1998). One further point regarding the study of religious and spiritual experiences is that these are subjective states that may have many different aspects and result from a variety of different approaches. We hope to present a relatively general approach to the neuropsychology of these states realizing that individual experiences ultimately must have unique physiological correlates. However, for neuroscience techniques to be useful, we must explore the general characteristics of these states first before proceeding to specific attributes of these states.

Methods of Attaining Spiritual Experiences

In considering a neuropsychological and neuroevolutionary approach to the study of religious and spiritual experiences, it is important to consider two major avenues towards attaining such experiences. These two basic categories are group ritual and individual contemplation or meditation. It must be understood that within these two general categories, there are thousands of possible approaches. Furthermore, there are also 'hybrids' such that individual meditation takes place as part of a group or when ceremonial ritual is performed by an individual. Even hybrid approaches can usually be classified into one category or the other. The major determining factor is whether or not the stimulation is from the external environment (i.e. via interindividual interaction, music, etc.) or whether the experience is being purely internally driven (i.e. via meditation, prayer, etc). However, it is probably helpful to consider these two broad categories rather than focus on highly specific practices if general neurophysiological models of such practices are to be developed. Thus, we do not intend in this paper to relate specific practices and experiences to neuropsychological correlates; instead, we endeavour to develop general principles from which detailed neuropsychological models of specific experiences and practices can be developed. A phenomenological analysis of group and individual practices reveals that they are similar in kind, if not in intensity, along two dimensions: (1) intermittent emotional discharges involving

the subjective sensation of awe, peace, tranquillity, or ecstasy; and (2) varying degrees of unitary experience correlating with the emotional discharges just mentioned (d'Aquili & Newberg, 1993). These unitary experiences may consist of a decreased sense or awareness of the boundaries between the self and the external world (d'Aquili & Newberg, 1993; Smart, 1969; 1978; Stace, 1961). The latter dimension can also lead to a sense of oneness with other practitioners thereby generating a sense of community. At the extreme, unitary experiences can eventually lead to a state of undifferentiated oneness with consequent abolition of all boundaries of discrete being (d'Aquili & Newberg, 1993).

It should be noted that the experiences of group ritual and individual meditation have a certain degree of overlap such that each may play a role in the other. In fact, it may be that human ceremonial ritual actually provides the 'average' person access to mystical experience ('average' in distinction to those regularly practising intense contemplation such as highly religious monks). This by no means implies that the mystic or contemplative is impervious to the effects of ceremonial ritual. Precisely because of the intense unitary experiences arising from meditation, mystics may be more affected by ceremonial ritual than the average person.

Brain Function and Structure

It may be helpful to consider the brain as having particular functions by which it interprets sensory input and thoughts (d'Aquili, 1978; 1983). We have previously called these functions cognitive operators. Cognitive operators refer to general methods or functions by which the brain interprets the world. These are not meant to be atomic in the sense that they represent specific, undivided modules of brain function, but rather refer to global functions. Furthermore, the cognitive operators can be attributed to the function of complex neuronal interactions, sometimes involving a number of brain structures. The cognitive operators include the application of quantitation to sensory and cognitive input, the abstraction of generals from particulars, the perception of spatial or temporal sequences in external reality, and the ordering of elements of reality into causal chains giving rise to explanatory models of the external world whether scientific or mythical. It should be mentioned that the cognitive operators are similar to the concept of cognitive modules in that both refer to functions of the brain that are based on certain neural interactions. However, we have usually used to the term cognitive operator to describe very broad or overarching functions while cognitive modules usually refer to more specific functions. For example, what we refer to as the 'quantitative operator' implies the brain's functional ability to manipulate and utilize numbers. Several investigators have demonstrated specific quantitative modules in the brain that perform specific numerical applications (Dahaene, 1997). There is certainly some overlap between the two concepts and the evidence to support one usually could be utilized for the other.

With regards to religious and spiritual experiences, several of the operators we have previously described require consideration. The causal operator refers to the

brain's ability to perform causal ordering of events in reality as experienced by sensory perception (d'Aquili, 1978). The ability to derive causality from events in the external world appears to result primarily from the functioning of the inferior parietal lobule in the left hemisphere, the anterior convexity of the frontal lobes, primarily in the left hemisphere, and their reciprocal neural interconnections (Luria, 1966; Pribram, 1973; Mills & Rollman, 1980). This causal function of the brain organizes any set of events in reality into what is subjectively perceived as causal sequences back to some original event. In view of the apparently universal human trait of positing causes for any given event, we postulate that if some original causal event is not given by sense data, the brain automatically generates such an event. The Western scientific method refuses to postulate an initial terminus or first cause for any strip of reality unless it is observed or can be immediately inferred from observation. We propose that when no observational or 'scientific' causal explanation is forthcoming for a strip of reality, some other causative construct is automatically generated by the causal operator. Thus, the brain simply operates spontaneously on reality, positing an initial causal terminus when none is given. This function often constructs various myths filled with personalized power sources (i.e. God, gods, spirits, etc.) to explain the world.

A second operator that has particular significance regarding spiritual experience is the holistic operator. The holistic operator refers to the brain's ability to view reality as a whole or as a gestalt. This operator allows for the abstraction from particulars or individuals into a larger contextual framework. The parts of the brain responsible for holistic operations likely resides in the parietal lobe in the non-dominant hemisphere, more specifically, in the posterior superior parietal lobule and adjacent areas that have been found to be involved in generating gestalt understanding about both sensory input and various abstract concepts (Schiavetto *et al.*, 1999; Gazzaniga & Hillyard, 1971). It is interesting that this area sits opposite to the area in the dominant hemisphere that provides the neuroanatomical substrate for logical-grammatical operations. Thus, the right parietal lobe is involved in the generation of a holistic approach to things and the left parietal lobe is involved in more reductionist/analytical processes.

A Neurophysiological Review

Any understanding of the neuropsychological basis of spiritual experience necessarily requires at least a basic understanding of neurobiology. Therefore, it is helpful to consider here the neurobiological concepts that are particularly relevant to spiritual experience. We will consider some of the major anatomical and functional components of human neurobiology. Furthermore, we will try to build this review using a 'bottom-up' approach, considering the more primitive evolutionary aspects first and finishing with the cerebral cortex.

The autonomic nervous system

The autonomic nervous system is responsible, in conjuction with the rest of the brain, for maintaining baseline body functions. Thus, this system keeps us alive,

but also plays a crucial role in the overall activity of the brain as well as in the generation of fundamental emotions such as fear. The autonomic nervous system is traditionally understood to be composed of two sub-systems, the sympathetic and parasympathetic system (Hugdahl, 1996; or for a detailed discussion of the autonomic nervous system please see Kandel *et al.*, 2000). The sympathetic system is responsible for the so-called fight-or-flight response which is the physiological basis of our adaptive strategies either to noxious stimuli or to highly desirable stimuli in the environment (Gellhorn, 1967; Gellhorn & Loofbourrow, 1963). Since the functions of the sympathetic nervous system are involved in the expenditure of the body's energy and metabolism, the total of the sympathetic system with its associated brain structures has been called the ergotropic system (Lex, 1979).

The parasympathetic system, on the other hand, is responsible for maintaining homeostasis (Gellhorn, 1967; Gellhorn & Loofbourrow, 1963). Since the functions of the parasympathetic nervous system are involved with the conservation of body energy and the maintenance of baseline metabolism, the total of the parasympathetic system with its associated brain structures has been called the trophotropic system (Lex, 1979).

The ergotropic and trophotropic systems have often been described as 'antagonistic' to each other, but they can be complementary to each other under certain conditions. Normally, the increased activity of one tends to produce decreased activity in the other. Each system is designed to inhibit the functioning of the other under most circumstances. However, studies have shown that if either system is driven to maximal stimulation, one can induce 'reversal' or 'spillover' phenomena (Gellhorn & Keily, 1972; Hugdahl, 1996). This spillover phenomenon occurs when continued stimulation of one system to maximal capacity begins to produce activation responses (rather than inhibitory) in the other.

We have proposed, in a previous work (d'Aquili & Newberg, 1999), five basic categories of ergotropic/trophotropic events and their sensorial concomitants which may occur during extraordinary phases of consciousness. The Hypertrophotropic State in which trophotropic activity is exceptionally high, may result in extraordinary states of quiescence. This activity can occur during normal sleep but may occur during deep meditation, prayer, or other related activities. The Hyperergotropic State occurs when ergotropic activity is exceptionally high. This results in an extraordinary state of unblocked arousal and excitation and is associated with keen alertness and concentration in the absence of superfluous thought and fantasy (Czikszentmihalyi, 1975).

The next two autonomic states involve hyperactivation of one system with spillover into excitation of the other system. Thus, the Hypertrophotropic State with Ergotropic Eruption is the state when trophotropic activity is so extreme that 'spillover' occurs and the ergotropic system becomes activated (Gellhorn & Kiely, 1972). During certain types of meditation, for example, we have proposed that as the hypertrophotropic state creates a sense of oceanic bliss, the ergotropic eruption results in the experience of a sense of a tremendous release of energy. The Hyperergotropic State with Trophotropic Eruption occurs when ergotropic

activity is so extreme that 'spillover' occurs and the trophotropic system becomes activated. This may be associated with the experience of an orgasmic, rapturous, or ecstatic rush, arising from a generalized sense of flow and resulting in a trance-like state.

There is recent evidence of unusual autonomic fluctuations during meditative states in which there was a significant increase in heart rate oscillations during both Qigong meditation and Kundalini Yoga meditation (Peng *et al.*, 1999). The authors concluded that there is a complex pattern of autonomic activity, involving both sympathetic and parasympathetic systems, that is occurring during these meditative practices.

The fifth and final state involves maximal stimulation of both the ergotropic and trophotropic systems (d'Aquili & Newberg, 1993). We have postulated that this state is likely associated with the most intense forms of mystical experience and may lie at the heart of compelling spiritual experiences, meditative states, near death experiences, and other types of human experiential phenomena (d'Aquili & Newberg, 1993; Newberg & d'Aquili, 1994). While, it is difficult to test such a hypothesis due to the difficulty of isolating these experiences, we can utilize what studies have actually been performed to consider how such experiences might occur.

Brain structure and function

The brain itself is divided into a number of subdivisions. The first subdivision separates the brain into a left and right hemisphere. The cerebral hemispheres are generally regarded as the seat of higher level cognitive and emotional functions. It is known that the cerebral cortex likely underlies the development of complex thought, language, religion, art and culture.

In addition to the cerebral cortex, there are a group of structures near the base of the brain that are called the limbic system. The limbic system is associated with the more complex aspects of emotions and is involved with assigning emotional feelings to various objects and experiences and directing these emotions outward via behaviour (Damasio, 1994;1999). The limbic system is also interconnected with the ergotropic and trophotropic components of the autonomic nervous system via the hypothalamus. The limbic system has also been implicated as having a major role in religious and spiritual experiences (d'Aquili & Newberg, 1993; Saver & Rabin, 1997; Joseph, 2000).

The hypothalamus is one of the most ancient structures in the brain from an evolutionary perspective. The medial part of the hypothalamus is an extension of the trophotropic system into the brain while the lateral hypothalamus seems to be an extension of the ergotropic system into the brain (Smith *et al.*, 1990). The amygdala is more recently developed evolutionarily than the hypothalamus and is preeminent in the control and modulation of higher order emotional and motivational functions, particularly those pertaining to arousal or fear (Morris *et al.*, 1996). In addition to emotional and motivational functioning, the amygdala is also involved in attention, learning, and memory. The function of the amygdala is

complex and although it has primarily an ergotropic function, it also has some functions usually attributable to trophotropic activity (Davis, 1992).

The final structure of the limbic system that requires discussion is the hippocampus. A number of investigators have assigned a major role to the hippocampus in information processing, including memory, new learning, cognitive mapping of the environment, and focusing attention. The hippocampus is greatly influenced by the amygdala, which in turn monitors and responds to hippocampal activity (Halgren, 1992). The hippocampus and amygdala complement each other and interact in regard to attention and generation of emotionally linked images, as well as in regard to learning and memory. The hippocampus also partially regulates the activity in another structure that connects the autonomic nervous system to the cerebral cortex called the thalamus (Green & Adey, 1956). Since the thalamus is a major relay between a variety of brain structures, the hippocampus can sometimes block information input to various brain structures via the thalamus. It is important to note that while the amygdala may enhance information transfer between brain regions, the hippocampus usually tends to do the reverse. Through interconnections with the amygdala and the hypothalamus, the hippocapmus can also prevent emotional extremes (Redding, 1967). This ability to inhibit the transfer of information from one region to another, in addition to its control over emotional responses will prove to be very important in generating certain experiences related to religious and spiritual experiences.

Association areas

As we return to the cerebral cortex with its structures involved in higher cognitive, sensory, and emotional functioning, we note that there are four association areas that integrate neuronal activity from various other areas in the brain. These cortical regions are the posterior superior parietal lobule (PSPL), the inferior temporal lobe (ITL), the inferior parietal lobule (IPL), and the prefrontal cortex (PFC).

The PSPL is heavily involved in the analysis and integration of higher order sensory information. Through the reception of auditory and visual input, the PSPL is also able to create a three dimensional image of the body in space (Lynch, 1980). There is some difference in function between the PSPL on the right and the PSPL on the left. It has been observed that the right parietal lobe appears to play an important role in generalized localization and the sense of spatial coordinates, whereas the left PSPL exerts influences in regard to objects that may be directly grasped and manipulated (Mountcastle, 1976). That some neurons in the left PSPL respond most to stimuli within grasping distance, and other neurons respond most to stimuli just beyond arms reach suggests that the distinction between self and other may, in part, arise from the left PSPL's ability to judge these two categories of distances. Thus, it seems probable that the self-other dichotomy is a left PSPL function that evolved from its more primitive division of space into the graspable and the non-graspable.

The ITL neurons scan the entire visual field so as to alert the organism to objects of interest or motivational importance through its interconnections with the limbic nuclei. Brain imaging studies using PET have also shown that the ITL

and PSPL are involved in the visual perception and learning of complex geometric patterns (Roland & Gulyas, 1995).

The IPL is located at the confluence of the temporal, parietal, and occipital lobes. The IPL is an association area of association areas, and maintains rich interconnections with the visual, auditory, and somaesthetic association areas. This area is generally regarded as responsible for the generation of abstract concepts and relating them to words.

The prefrontal cortex is the only area that receives afferent fibres from all sensory modalities, as well as from the other association areas (Fuster, 1997). The prefrontal cortex is involved in mediating concepts via its rich interconnections with the inferior parietal lobe (Stuss & Benson, 1986). Also, and importantly for our concerns here, the prefrontal cortex of each hemisphere is connected to the prefrontal cortex of the other by connecting nerve fibres (Stuss & Benson, 1986).

In humans, the loss of the ability to concentrate is a characteristic feature of any prefrontal disorder, as is the loss of the ability to plan and to orient oneself to future behaviour (Frith *et al.*, 1991). Patients with prefrontal lesions not only lose the ability to plan and orient themselves to future activity, but they also suffer a severe deficit in carrying out complex perceptual and conceptual tasks. Patients with prefrontal disorders also exhibit flatness of affect and apathy and tend to have difficulty controlling emotion (Fuster, 1997; Stuss & Benson, 1986). To put it bluntly, a great part of what one sees with this disorder 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 prefrontal cortex (Frith *et al.*, 1991).

Deafferentation

One other aspect of brain function that may play an important role in spiritual experience is the ability of certain brain structures to block input into other structures. This blocking of input into a brain structure is called deafferentation. There is much evidence of such phenonena arising from natural (i.e. stroke or neuronal degeneration) or induced lesions in various parts of the brain (Baron *et al.*, 1986; Gilbert & Peterson, 1991; Jeltsch *et al.*, 1994; Kataoka *et al.*, 1991). Deafferentation of a brain structure also can occur via the activity of inhibitory fibres from other nervous system structures. For example, it has been shown that one hemisphere can be prevented from knowing what is occurring in the opposite hemisphere by the inhibitory or deafferenting actions of the frontal lobes (Hoppe, 1977). There is similar evidence that intrahemispheric information transmission can be partially or totally prevented via impulses originating in the prefrontal cortex and passing via the hippocampus (Green & Adey, 1956; Joseph *et al.*, 1981).

When a brain structure that ordinarily processes input has been deafferented to a significant degree, the structure is required to function upon its own random neural activity (Lilly, 1972). For example, a deafferented area of the brain that normally functions to analyse visual input will tend to interpret any neural activity as visual input resulting in a visual hallucination. Such hallucinations occur in patients with cortical blindness in which the association areas and primary visual areas are disconnected.

Neurophysiological Studies of Spiritual Experiences

A number of different types of studies have been performed to try to specifically investigate the neurophysiological correlates of spiritual experiences. Originally, studies analysed the relationship between electrical changes in the brain (measured by electroencephalography) and meditative states. Corby, Roth, Zarcone, & Kopell (1978) showed that during Tantric yoga meditation, proficient practitioners had increased alpha and theta amplitudes compared to baseline. These changes were associated with increased autonomic activation. Banquet (1972) found an increased intensity of a frontal alpha pattern during the early stages of meditation. Another study found hemispheric asymmetries in alpha and beta activity associated with Buddhist *g Tum-mo* yoga meditation (Benson *et al.*, 1990). Unfortunately, EEG is limited in its ability to distinguish particular regions of the brain that may have increased or decreased activity.

For this reason, more recent studies of meditation have utilized brain imaging techniques such as single photon emission computed tomography (SPECT) and positron emission tomography (PET). We have previously presented data from SPECT images measuring cerebral blood flow (which correlates with activity) obtained on highly proficient Tibetan Buddhist meditators during a form of *vajrayana* meditation (Newberg *et al.*, 1997a,b). Baseline and meditation scans were compared with regions of interest (ROIs) drawn around specific brain structures. The activity in these ROIs were compared to determine the relative changes that occurred during meditation. Our preliminary results showed significant increases in brain activity in the region comprising the PFC consistent with focusing attention on a visualized image during meditation. We have also observed relatively decreased activity in the area of the PSPL possibly consistent with deaferentation the PSPL. Interestingly, there was also a strong inverse correlation between activity in the PFC and in the PSPL. This might indicate that the more active the PFC is, the more the PSPL is deafferented. These results, although preliminary, are consistent with the model for the neurophysiological basis of meditative experiences presented in this chapter, which was developed and published before these brain imaging studies were embarked upon. Further, our results corroborate an earlier PET study of a yoga meditative relaxation technique that showed an increased frontal:occipital ratio of cerebral glucose metabolism (Herzog *et al.*, 1990–91). A more recent study demonstrated changes in the temporal lobes, frontal lobes, and parietal lobes associated with yoga relaxation techniques (Lou, 1999).

In all, these studies can provide a starting point to develop a more detailed model of the neurophysiological correlates of religious and spiritual experiences. This kind of model can also be utilized as the hypothesis for future investigations of such experiences.

A Neurophysiological Model for Religious and Spiritual Experiences

It appears that there are a variety of spiritual experiences which, although they seem to be fundamentally different, actually have certain neuropsychological

similarities. In terms of spiritual experiences, unitary states appear to play an important role. In fact, we might consider spiritual experiences to lie along a 'unitary continuum' with multiple discrete being at one end and complete unitary experiences at the other.

A neurobiological analysis of mysticism and other spiritual experiences might elucidate the continuum of these experiences by allowing for a typology based on the underlying brain functions. In terms of the effects of ceremonial ritual we, along with other colleagues, have proposed that rhythmicity in the environment drives either the ergotropic or trophotropic system to maximal capacity (Lex, 1979; Iwanaga & Tsukamoto, 1997) with the possibility of spillover and simultaneous activation of the other system creating unusual subjective states (Gellhorn & Kiely 1972; d'Aquili, 1983; Bernston *et al.*, 1991; d'Aquili & Newberg, 1993; Hugdahl, 1996). For the most part, this neurophysiological activity occurs as the result of the rhythmic driving of ceremonial ritual. We have postulated that this ultimately results in a progressive deafferentation of certain parts of the right PSPL, creating an increasing sense of wholeness progressively more and more dominant over the sense of the multiplicity of baseline reality. Ceremonial ritual may be described as generating these spiritual experiences from a bottom-up approach, since it is through rhythmic sounds and behaviours that ritual eventually drives the ergotropic and trophotropic systems. It should also be mentioned that the particular system initially activated (ergotropic or trophotropic) depends upon the type of ritual. Rituals themselves might therefore be divided into 'slow' and 'fast' ritual (d'Aquili & Newberg, 1999). Slow rituals might involve calm, peaceful music and soft chanting to generate a sense of quiescence via the trophotropic system. Fast rituals might utilize rapid or frenzied dancing to generate a sense of heightened arousal via the ergotropic system.

However, activation of the holistic operator (the right PSPL and adjacent structures) and the attainment of ecstatic and blissful unitary states can also be achieved via other mechanisms. For example, meditation approaches the situation from the opposite direction as that of ceremonial ritual (d'Aquili & Newberg, 1993). Meditation appears to utilize a 'top-down' mechanism using cognitive/emotional activity to drive the ergotropic / trophotropic systems to maximum activation. This appears to occur via a complex mechanism of neural interactions.

A detailed mechanism for the neurophysiological basis of meditative experiences has been previously described (d'Aquili & Newberg, 1993). However, it may be helpful to review some of the major components of that model in order to develop a better understanding of the spiritual continuum. Some forms of meditation begin with the subject willing or intending to focus either on a mental image or on an external physical object. This initially results in activation of the right PFC which activates the right PSPL via the thalamus which functions as a relay. These impulses are correlated with the person subjectively focusing their attention on a visual object. This object, presented by the ITL, is oriented by the PSPL. Thus, there is a relative increase in stimulation between the right PFC, the ITL, and the PSPL.

We postulate that continuous fixation on the image presented by the right ITL begins to stimulate the right hippocampus, which in turn stimulates the right amygdala. The result is a stimulation of the lateral portions of the hypothalamus generating a mildly pleasant, alert sensation. Impulses then pass back to the right amygdala and hippocampus recruiting intensity as they go along. This then feeds back to the right PFC reinforcing the whole system with progressively intense concentration upon the object. Thus, a reverberating loop is established.

In our model, the circuit continues to reverberate and to augment in intensity until the stimulation of the hypothalamic ergotropic centres (lateral part) reaches maximum thus leading to a 'spillover' such that maximal stimulation of the hypothalamic trophotropic centers (medial part) occurs. At this point, there would be maximal stimulation feedback through the limbic structures to both the left and right PFC. This then results in instantaneous maximal stimulation of the left PFC with immediate total blocking of input into the left PSPL which may be associated with the obliteration of the Self–Other dichotomy. In the right hemisphere, there is already an ongoing, powerful stimulation system from the right PFC to the right PSPL which blocks the ability of the right PFC to deafferent the PSPL. This stimulation has been reinforced by a constant feedback loop going through the right ITL (the neurophysiological basis of 'focusing on an object').

Therefore, the inhibitory ability of the right PFC, although at maximum, must fight against a pre-existent, and very strong, facilitatory or stimulating system that is generated by fixating and focusing upon the original object. Since the meditating subject is still intending to focus on the object of meditation, this system continues to be reinforced even in the presence of ecstatic feelings generated by the limbic system and the progressively stronger activity of the inhibitory system. Throughout the period of time when there is conflict in the right hemisphere between facilitatory and inhibitory mechanisms there has been total instantaneous blocking of input into the left PSPL. Thus, the Self–Other dichotomy has been obliterated during a period of time, perhaps fairly long, when the image still remains a focus of meditation. We would suggest that this is the period of time when the subject feels absorbed into the object or describes a sense of becoming one with the object of meditation. Eventually, in the face of maximal ergotropic and trophotropic activity, either the meditator surrenders, or possibly even against his/her will, the inhibitory influences take over and total blocking of input into the right PSPL occurs. Since the left PSPL has already been totally blocked, the Self–Other dichotomy has been obliterated for some time. Thus, the endpoint of the meditation is maximal stimulation of the ergotropic and trophotropic systems with total blocking of input into both the right and left PSPL, resulting in the most profound unitary state attainable. The period of time from spillover to the final assertion of dominance of the inhibitory neurons of the right prefrontal cortex is the period of absorption of the meditator into the object of meditation.

It should be mentioned here that there is a distinction between the experience associated with a totally deafferented right PSPL and a totally deafferented left PSPL. Total deafferentation of the left PSPL is likely associated with the obliteration of the self/other dichotomy and we believe that the resulting experience is a

sense of union between the self and the object of meditation which is often God, Brahman, etc. The important point is that deafferentation is associated with the sense of union with something outside of the self. On the other hand, total deafferentation of the right PSPL is most likely associated with the loss of usual orientation with regards to space and time. Since all input into this structure is blocked, it results in an orientation towards nothing. We have previously suggested that this may be experienced as a sense of complete nothingness, or possibly infiniteness. Thus, experiences in which both the left and right PSPL are totally deafferented should result in the sense of a merging of the self with all that is (e.g. emtiness experiences).

In returning to a comparison of ceremonial ritual with meditation, the end result can be the same in both situations (d'Aquili and Newberg, 1993). In other words, both methods can result in simultaneous activation of the ergotropic and trophotropic systems as has been described above, with concommitant deafferentation of the left and right PSPL. This results in the experience of bliss and ecstasy as well as in profound unitary states. It should be noted that the most profound unitary states are unlikely to occur in ceremonial ritual since it is very difficult to maintain the level of rhythmic activity necessary for the continued driving of the ergotropic system to result in simultaneous maximal activity of both the ergotropic and trophotropic systems. However, ceremonial ritual still can result in powerful unitary experiences.

While it is difficult to define what makes a given experience spiritual, the sense of having a union with some higher power or fundamental state seems an important part of spiritual experiences. To that end, this union helps reduce existential anxiety as well as provide a sense of control over the environment (d'Aquili, 1978; Smart, 1969). The bottom line in understanding the phenomenology of subjective religious experience is to understand that every religious experience involves a sense of the unity of reality at least somewhat greater than the baseline perception of unity in day to day life (d'Aquili & Newberg, 1999). This is another way of saying that a more intense application of the holistic operator to incoming stimuli, over and above its baseline function, coupled with the limbic or emotional stimulation that accompanies such increased functioning, results in experiences which are usually described as religious or spiritual.

We are proposing that the unitary continuum is based upon the activation of this holistic operation with the subsequent experience of greater senses of unity within the sensorium. As there is an increasing sense of unity, there is the perception of ever greater approximations of a more fundamental reality (d'Aquili & Newberg, 1999). The more the holistic operator functions in excess of a state of balance with the analytic functions of the left hemisphere, the stronger will be the associated emotional charge. Thus, in any perception such as a piece of music, a painting, a sculpture, or a sunset, there is a sense of meaning and wholeness that transcends the constituent parts. In aesthetic perceptions such as those just described, this transcendence may be slight to moderate. We would locate the overarching sense of unity between two persons in romantic love as the next stage in this spiritual continuum. The next stages proceed through a sense of

numinosity or religious awe to the state of religious exaltation which Bucke has called Cosmic Consciousness (Bucke, 1961). This state is characterized by a sense of meaning and wholeness extending to all discrete being whether subjective or objective. The essential unity and purposefulness of the universe is perceived as a primary datum despite the perception and knowledge of evil in the world. During this state, there is nothing whatsoever that escapes the mantle of wholeness and purposefulness. But this state does not obliterate discrete being, and it certainly exists within a temporal context.

In the most profound unitary states, a person looses all sense of discrete being and even the difference between self and other is obliterated. There is no sense of the passing of time, and all that remains is a perfect timeless undifferentiated consciousness. However, it is important to realize that the limbic system is intimately involved in the perception of these experiences (Saver & Rabin, 1997). Thus, when such a state is suffused with positive affect there is a tendency to describe the experience, after the fact, as personal. Such experiences are often described as a perfect union with God (the *Unio mystica* of the Christian tradition) or else the perfect manifestation of God in the Hindu tradition. When such experiences are accompanied by neutral affect they tend to be described, after the fact, as impersonal. These states are described as the Absolute of a number of philosophical/mystical traditions. There is no question that whether the experience is interpreted personally as God or impersonally as the Absolute it nevertheless possesses a quality of transcendent wholeness without any temporal or spatial division whatsoever.

We have postulated that these rare states of undifferentiated unity are attained through the 'absolute' functioning of the holistic operator (d'Aquili, 1982; d'Aquili & Newberg, 1993). As described in the model above, the neurological substrate for the holistic operator involves the function of the right PSPL. However, there also would be an intense activity of structures in the left cerebral hemisphere associating with that wholeness the intense consciousness of the reflexive ego associated with normal left hemispheric functioning. Thus, the state of undifferentiated unity may actually be experienced as one of intense consciousness.

Conclusion: Proof of the Model

Clearly, one of the most important aspects of a neuroscientific study of spiritual experiences is to find careful, rigorous methods for empirically testing hypotheses. One such example of empirical evidence for the neurophysiological basis of spiritual experiences comes from the studies already described which have measured neurophysiological activity during religious and spiritual experiences. Meditative states comprise perhaps the most fertile testing ground because of the predictable, reproducible, and well described nature of such experiences. Studies of meditation have evolved over the years to utilize the most advanced technologies for studying neurophysiology. Such techniques include EEG, fMRI, SPECT, and PET imaging. While the initial findings are promising, more studies, with improved methods will be necessary to further elucidate the neuropsychology of

religious and spiritual experiences. Furthermore, different spiritual experiences might be studied to compare and contrast the phenomenology with specific physiological states. That the underlying neurophysiology of extreme spiritual states can be considered at all allows for the eventual conceptualization of a neuropsychology of religious and spiritual experiences.

References

Banquet, J.P. (1972), 'EEG and meditation', *Electroencephalography and Clinical Neurophysiology*, **33**, pp. 454.

Baron, J.C., D'Antona, R., Pantano, P., Serdaru, M., Samson, Y. and Bousser, M.G. (1986), 'Effects of thalamic stroke on energy metabolism of the cerebral cortex. A positron tomography study in man', *Brain*, **109**, pp. 1243–59.

Benson, H., Malhotra, M.S., Goldman, R.F., Jacobs, G.D. and Hopkins, J. (1990), 'Three case reports of the metabolic and electroencephalographic changes during advanced Buddhist meditation techniques', *Behavioral Medicine*, pp. 90–5.

Berntson, G.G., Cacioppo, J.T. and Quigley, K.S. (1991), 'Autonomic determinism: the modes of autonomic control, the doctrine of autonomic space and the laws of autonomic constraint', *Psychological Review*, pp. 459–87.

Bucke, R.M. (1961), *Cosmic Consciousness* (Secaucus, NJ: Citadel Press).

Corby, J.C., Roth, W.T., Zarcone, V.P. and Kopell, B.S. (1978), 'Psychophysiological correlates of the practice of Tantric Yoga meditation', *Archives of General Psychiatry*, **35**, pp. 571–7.

Czikszentmihalyi, M. (1975), *Beyond Boredom and Anxiety* (San Francisco, CA: Jossey-Bass).

Damasio, A.R. (1994), *Descartes' Error: Emotion, Reason, and the Human Brain* (New York: Avon Books, Inc.).

Damasio, A.R. (1999), *The Feeling of What Happens: Body and Emotion in the Making of Consciousness* (New York: Harcourt Brace & Company).

d'Aquili, E.G. (1978), 'The neurobiological bases of myth and concepts of deity', *Zygon*, **13**, pp. 257–75.

d'Aquili, E.G. (1982), 'Senses of reality in science and religion', *Zygon*, **17** (4), pp. 361–84.

d'Aquili, E.G. (1983), 'The myth-ritual complex: A biogenetic structural analysis', *Zygon*, **18**, pp. 247–69.

d'Aquili, E.G. and Newberg, A.B. (1993), 'Religious and mystical states: a neuropsychological model, *Zygon*, **28**, pp. 177–200.

d'Aquili, E.G. and Newberg, A.B. (1999), *The Mystical Mind: Probing the Biology of Religious Experience* (Minneapolis, IN: Fortress Press).

Davis, M. (1992), 'The role of the amygdala in fear and anxiety', *Annual Review of Neuroscience*, **15**, pp. 353–75.

Dehaene, S. (1997), *The Number Sense* (New York: Oxford University Press).

Frith, C.D., Friston, K., Liddle, P.F. and Frackowiak, R.S.J. (1991), 'Willed action and the prefrontal cortex in man. a study with PET', *Proceedings of the Royal Society of London*, **244**, pp. 241–6.

Fuster, J.M. (1997), *The Prefrontal Cortex: Anatomy, Physiology, and Neuropsychology of the Frontal Lobe*, 3rd Edition (Philadelphia, PA: Lippincott-Raven).

Gazzaniga, M.S. and Hillyard, S.A. (1971), 'Language and speech capacity of the right hemisphere', *Neuropsychologia*, 9, pp. 273–80.

Gellhorn, E. and Loofbourrow, G.N. (1963), *Emotions and Emotional Disorders: A Neurophysiological Study* (New York: Norton).

Gellhorn, E. and W.F. Kiely. (1972), 'Mystical States of Consciousness: Neurophysiological and Clinical Aspects', *Journal of Nervous and Mental Disease*, **154**, pp. 399–405.

Gellhorn, E. (1967), *Principles of Autonomic-Somatic Integration: Physiological Basis and Psychological and Clinical Implications* (Minneapolis, IN: University of Minnesota Press).

Gilbert, M.E. and Peterson, G.M. (1991), 'Colchicine-induced deafferentation of the hippocampus selectively disrupts cholinergic rhythmical slow wave activity', *Brain Research*, **564** (1), pp. 117–26.

Green, J.D. and Adey, W.R. (1956), 'Electrophysiological studies of hippocampal connections and excitability', *Electroencephalography and Clinical Neurophysiology*, **8**, pp. 245–62.

Halgren, E. (1992), 'Emotional neurophysiology of the amygdala within the context of human cognition', in *The Amygdala*, ed. J.P. Aggleton (New York: Wiley-Liss).

Herzog, H., Lele, V.R., Kuwert, T., Langen, K-J., Kops, E.R. and Feinendegen, L.E. (1990–91), 'Changed pattern of regional glucose metabolism during Yoga meditative relaxation', *Neuropsychobiology*, **23**, pp. 182–7.

Hoppe, K.D. (1977), 'Spilt brains and psychoanalysis', *Psychoanalytic Quarterly*, 46, pp. 220–44.

Hugdahl, K. (1996), 'Cognitive influences on human autonomic nervous system function', *Current Opinion in Neurobiology*, **6**, pp.252–8.

Iwanaga, M. and Tsukamoto, M. (1997), 'Effects of excitative and sedative music on subjective and physiological relaxation', *Perceptual and Motor Skills*, **85**, pp. 287–96.

Jeltsch, H., Cassel, J.C. Jackisch, R., Neufang, B., Greene, P.L., Kelche, C., Hertting, G. and Will, B. (1994), 'Lesions of supracallosal or infracallosal hippocampal pathways in the rat: behavioral, neurochemical, and histochemical effects', *Behavioral and Neural Biology*, **62** (2), pp. 121–33.

Joseph, R. (2000), *The Transmitter to God: The Limbic System, the Soul, and Spirituality* (San Jose: University Press California).

Joseph, R., Forrest, N., Fiducis, D., Como, P. and Siegal, J. (1981), 'Behavioral and electrophysiological correlates of arousal', *Physiological Psychology*, **9**, pp. 90–5.

Kandel, E.R., Schwartz, J.H. and Jessell (2000), *Principles of Neural Science* (New York: Elsevier Science Publishing Co., Inc).

Kataoka, K., Hayakawa, T., Kuroda, R., Yuguchi, T. and Yamada, K. (1991), 'Cholinergic deafferentation after focal cerebral infarct in rats', *Stroke*, **22** (10), pp. 1291–6.

Laughlin, C.D. and d'Aquili, E.G. (1974), *Biogenetic Structuralism* (New York: Columbia University Press).

Lex, B. (1979), 'The neurobiology of ritual trance', in *The Spectrum of Ritual: A Biogenetic Structural Analysis*, ed. E.G. d'Aquili, C.D. Laughlin Jr. and J. McManus (New York: Columbia University Press).

Lilly, J.C. (1972), *The Center of the Cyclone* (New York: Julian Press).

Lou, H.C., Kjaer, T.W., Friberg, L., Wildschiodtz, G., Holm, S. And Nowak, M. (1999), 'A ^{15}O-H_2O PET study of meditation and the resting state of normal consciousness', *Human Brain Mapping*, **7**, pp. 98–105.

Luria, A.R. (1966), *Higher Cortical Functions in Man* (New York: Basic Books).

Lynch, J.C. (1980), 'The functional organization of posterior parietal association cortex', *Behavioral and Brain Sciences*, **3**, pp. 485–99.

Mills, L. and G.B. Rollman. (1980), 'Hemispheric asymmetry for auditory perception of temporal order', *Neuropsychologia*, **18**, pp. 41–7.

Mountcastle, V.B. (1976), 'The world around us: neural command functions for selective attention', *Neurosciences Research Progress Bulletin*, **14**, pp. 1–47.

Morris, J., Frith, C.D., Perrett, D., Rowland, D., Young, A.W., Calder, A.J. and Dolan, R.J. (1996), 'A differential neural response in the human amygdala to fearful and happy facial expressions, *Nature*, **383**, pp. 812–15.

Newberg, A.B. and Alavi, A. (1996), 'The study of the neurological disorders using positron emission tomography and single photon emission computed tomography', *Journal of the Neurological Sciences*, **135**, pp. 91–108.

Newberg, A., Alavi, A., Baime, M. and d'Aquili, E. (1997a), 'Cerebral blood flow during intense meditation measured by HMPAO-SPECT: A preliminary study', American College of Nuclear Physicians Annual Meeting, Palm Springs, California.

Newberg, A., Alavi, A., Baime, M., Mozley, P. and d'Aquili, E. (1997b), 'The measurement of cerebral blood flow during the complex cognitive task of meditation using HMPAO-SPECT imaging', *Journal of Nuclear Medicine*, **38**, pp. 95P.

Newberg, A.B., Alavi, A., Bhatnagar, A., Baime, M. and d'Aquili, E.G. (1998), 'The neurophysiological correlates of meditation: Implications for neuroimaging', *Journal of the Indian Academy of Clinical Medicine*, **3**, pp. 13–18.

Newberg, A.B. and d'Aquili, E.G. (1994), 'The near death experience as archetype: A model for 'prepared' neurocognitive processes', *Anthropology of Consciousness*, **5**, pp. 1–15.

Peng, C-K., Mietus, J.E., Liu, Y., Khalsa, G., Douglas, P.S., Benson, H. and Goldberger, A.L. (1999), Exaggerated heart rate oscillations during two meditation techniques', *International Journal of Cardiology*, **70**, pp. 101–7.

Pribram, K.H. (1973), 'The primate frontal cortex — Executive of the brain', in *Psychophysiology of the Frontal Lobes*, ed. K.H. Pribram and A.R. Luria (New York: Academic Press).

Redding, F.K. (1967), 'Modification of sensory cortical evoked potentials by hippocampal stimulation', *Electroencephalography and Clinical Neurophysiology*, **22**, pp. 74–83.

Roland, P.E. and Gulyas, B. (1995), 'Visual memory, visual imagery, and visual recognition of large field patterns by the human brain: functional anatomy by positron emission tomography', *Cerebral Cortex*, **5**, pp. 79–93.

Saver, J.L. and Rabin, J. (1997), 'The neural substrates of religious experience', *Journal of Neuropsychiatry and Clinical Neurosciences*, **9**, pp. 498–510.

Schiavetto, A., Cortese, F. And Alain, C. (1999), 'Global and local processing of musical sequences: An event related brain potential study', *Neuroreport*, **10**, pp. 2467–72.

Smart, N. (1969), *The Religious Experience of Mankind* (London: Macmillan).

Smart, N. (1978), 'Understanding religious experience', in *Mysticism and Philosophical Analysis*, ed. S. Katz (New York: Oxford University Press).

Smith, P.H., DeVito, J.L. and Astley, C.A. (1990), 'Neurons controlling cardiovascular responses to emotion are located in the lateral hypothalamus-perifornical region', *American Journal of Physiology*, **259**, pp. 943–54.

Stace, W.T. (1961), *Mysticism and Philosophy* (London: Macmillan).

Stuss, D.T. and Benson, D.F. (1986), *The Frontal Lobes* (New York: Raven).