The limbic system and the "religious brain"

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Background

The human body is a fascinating and complex array and composition of protoplasm that is arranged in cells, organs and other substructures. The body has one common goal: to survive. To ensure survival, the body has to be kept intact and protected from the outside world by the largest organ – the skin. Under the skin, a most fascinating array of cells and substructures are systematically and functionally arranged. These cells and organs are all bathed in a fluid that is called the interstitial fluid. This fluid seems to have the same constituents of sea water. The human organs are arranged in systems that have to

- circulate blood through the whole body – *the circulatory/cardiovascular system*
- deliver oxygen to the blood and clean it from carbon dioxide – *the respiratory system*
- take, digest and metabolise food, and excrete excessive and toxic metabolites – *the gastro-intestinal system*
- purify the blood from toxic metabolites, balance the blood components, and supply the seeds and tools for reproduction – *the urogenital system*
- protect the body against harmful invaders such as viruses and bacteria – *the immune system*
- supply the framework for mobility and protection – *the skeletal system*
- drive growth, sex and the hormonal aspects of the body – *the endocrine system*
- control the body through input and output and also feedback mechanisms – *the nervous system*

The human brain is the major controller of the body. It receives inputs from every organ of each system inside the body and makes appropriate adjustments at various levels to ensure the optimal function of the organ and ultimate survival. The brain also receives information from the external environment through the senses and makes appropriate adaptive adjustments on conscious and subconscious levels to maximise survival in a harsh external environment. The brain is therefore connected to both the internal and external environments of the body and constantly communicates with both environments. To achieve this, the brain is divided into various subcomponents. A complete description of the brain and all its components is beyond the scope of this paper; however, a few important subsystems that are relevant to the experience of religion and religious thoughts and feelings will be outlined briefly. Before these components are described, it is useful to explain a few basic brain facts.

Basic brain facts

The adult human brain weighs approximately 1400 grams. The brain consists of a number of cells that are arranged in similar fashion in most parts of the brain. A main brain cell is called a neuron. A neuron is an electrically active brain cell; it is hyper-excitable and receives and conveys impulses from and to other neurons through electrical currents. There are an estimated 100 billion neurons in the human brain. If there are 7000 million people on Earth, there will be approximately 14 neurons in your brain for every person. If this sounds unimpressive, consider that each neuron can make up to 10 000 connections with other neurons. The possible amount of connections is what makes the human brain such an incredible organ.

Neurons talk to each other through connections that are called synapses. Neurochemicals/substances, called neurotransmitters, are secreted when the electrical current reaches the synapse. The neurotransmitters bind on the connected neuron and start a new electrical current in the connected neuron. The speed of the current is increased greatly by the insulation of the neuron's major wire (axon) by a substance that is called myelin. Myelin wraps itself around the axon like small Swiss rolls and gives it the appearance of a string of sausages.

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Glial cells are another type of brain cells and are mainly supporting cells for the neurons. There are roughly 10 glial cells per neuron in the brain. Glial cells can be astrocytes, oligodendrocytes, microglia and ependymal cells.

A neuron consists of a stellate-shaped cell body, various tentacles that are called dendrites and receive inputs from various other neurons, and a long wire with myelination around it that is called the myelinated axon. The axon can branch into literally thousands of branches that connect widely with many other neurons with even different functions. The cell bodies are arranged and clumped together on the outer surface of the brain, which is called the cortex/gray matter. The axons dip into the brain and form major tracts with other axons to form the white matter. In the brain most of the axons connect with other neurons whose cell bodies are also clumped together to form nuclei/ganglia, for example the basal ganglia/thalamus. This forms the basis of brain function. The complexity of brain function lies in the amount of possible connections to various areas of the brain with the subsequent simultaneous activation of different brain components that result in a non-predicted non-linear outcome. Deterministically spoken, this is all there is; however, it is impossible to prove or verify that the brain is deterministic. Non-determinism, spirituality and the existence of the mystic realm are therefore accepted as a realistic possible explanation for complex brain behaviour.

The brain is evolutionary and ontologically divided into a few important functional areas and understanding these functional areas is important to conceptually understand religious experiences.

The brain stem and cerebellum

The brain stem is the part of the brain that connects the brain to the spinal cord. The cerebellum, also known as the "small brain", is in many ways part of the brain stem through its abundant connections and sharing of specific neural circuits. The brain stem has also been called the "primitive" part of the brain and the "survival" brain. The brain stem contains all the white matter tracts (clumps of axons of neurons) that run from the brain to the muscles of the body and from the receptor areas of the body to the brain. In addition, the brain stem contains the centres that control or significantly influence the so-called vital functions of the body. They are:

- cardiovascular control (heart and blood vessels)
- respiratory control (regulation of breathing)
- hunger and thirst centres
- sleep and wake cycles
- sexual functions

These are the most fundamental requirements for survival. Without the brain stem, there cannot be life. It is well known that patients who have suffered severe loss of oxygen to the brain can remain alive with an intact brain stem while the rest of their brains are no longer working. This is the so-called "vegetative state". The brain stem is therefore vital for life.

The limbic system

The limbic system is situated on top of the brain stem (see figure 1 of the addendum). Its name derives from the word "limbus", which is the Latin for "C-shape". The structures of the limbic system are organised in large C-shaped formations that almost hang on top of the brain stem. They are rather densely connected to the thalamus (a deep-seated nucleus that is situated right on top of the brain stem) in the central parts of the brain and are embedded in the newer parts of the brain towards the sides of the brain (called the temporal lobes and frontal lobes).

It is useful, at this point, to understand that all the components of the brain are interconnected and densely interrelated into one big whole. Therefore, the brain stem and the limbic system are not two completely separate structures but flow into each other in terms of structure and function. The limbic system is evolutionary younger than the brain stem, and developed to increase the human brain's capacity to act upon harmful and useful stimuli on the basis of memory.

The limbic system consists of a complex of nuclei/bodies which are intricately connected with each other through bundles of white matter. These nuclei include the hypothalamus, amygdala, hippocampus, septal nuclei, cingulate, parts of the thalamus and parts of the temporal lobe. The hypothalamus is the oldest part of the limbic system and deals with short-lived emotional responses of a generic nature. It is interesting to note that there is a hierarchy of increasingly sophisticated computations of emotional stimuli in the limbic system, the evolutionary youngest nuclei being the most sophisticated and discrete. The hierarchy is: hypothalamus–amygdala/hippocampus–septal

nuclei– anterior cingulate (for motivational emotional processes) and hypothalamus–amygdala/hippocampus–inferior temporal lobe (for the emotional aspects of memory). Thus the hypothalamus is evolutionary the oldest part of the limbic system and is closely associated with the vital functions of the brain stem; whereas the cingulate and the temporal lobe are the newest developments of the limbic system and already form part of the neocortex (new cortex).

Note that there are two hierarchical processes: one that connects the limbic system via the cingulate predominantly with the frontal lobe (see later) and another that connects the limbic system via the inferior temporal lobe with the neocortex (the newest part of the brain) via the parietal lobe. The limbic system also has direct connections with the motor cortex, which activates the motor system and muscles for immediate action to avoid threatening situations or engage in pleasure-seeking activities.

The hypothalamus

The hypothalamus mediates short-lived intense emotional responses. It is concerned with the optimal well-being of the internal state of the body and therefore controls and mediates urges and desires of hunger, thirst, sex, sleep, aggression and fleeing. It is commonly held that the hypothalamus mediates the four 'Fs', namely feeding, fighting, fleeing and fornication. The hypothalamus is also often regarded as the 'eye turned inward', which means that the hypothalamus monitors the inner state of the body and directs it appropriately through the nervous and endocrine systems. The hypothalamus can generate orgasmic sexual experiences through the release of opiates (morphine-like substances).

The amygdala

The amygdala or amygdaloid body is an almond-shaped structure that is situated in the most anterior (front portion) of the right and left temporal lobes. It is richly interconnected with the hypothalamus and therefore also shares some functional features with the hypothalamus. For example: The amygdala is active in the perception and expression of emotional states such as happiness, pleasure, sadness, fear and aggression through the release of neurotransmitters such as opiates, but its primary concern seems to be emotional information from the external environment. For this reason, the amygdala can be regarded as the "eye turned outward" that constantly scans and analyses the stimuli from the external world (through the senses such as smell, vision, sound, touch and taste), extracts the emotionally significant features and enables the cortex to act upon it appropriately. The amygdala therefore is integral in forming an internal representation of the outside world and is primarily concerned with emotional content. The amygdala, through its connections with the evolutionary older and younger elements of the limbic system, is able to construct visual images and scenarios that are rich in emotional content, with feelings of pleasure, rage, fear, happiness, etc.

The amygdala builds emotional memory into and receives emotionally rich memory from the hippocampus (see later). The amygdala–hippocampus connections are responsible for constructions of complex emotional memory and if activated, can enable a person to have mystical and religious experiences. This is often seen in patients who suffer from epilepsy that originates in this region.

The amygdala is often called the seat of emotional intelligence. It is centrally situated between the hypothalamus and the newer parts of the limbic system and can produce complex emotional experiences, especially with regard to sex, aggression, hunger/thirst responses and religion.

The hippocampus

The hippocampus, which literally means "sea horse" because its cross-sectional shape resembles that of a sea horse, is situated in a pair in the left and right temporal lobes in close proximity to the amygdala. It is primarily concerned with spatial, cognitive, verbal and recognition-type memory; whereas the amygdala is concerned with emotional memory. The amygdala and the hippocampus are connected and act in tandem as a duet to perceive and produce memories or neural processes that are rich in images, familiar and unfamiliar – and even mystical. (This is especially true of the right amygdala–hippocampus complex). These images are filled with abundant emotional content through the contributions of the amygdala. The amygdala and hippocampus are in turn richly connected with the inferior (lower part) temporal lobe. This is a part of the cortex that is strongly connected and interactive with the neocortex (newer, rational brain).

The amygdala–hippocampus complex and inferior temporal lobe

The concerted activations of the amygdala–hippocampus complex and the inferior temporal lobe facilitate the human experience of mystical and religious experiences (Joseph 1996:278–283). These are mostly situated in the right cerebral hemisphere (right brain) and also involve the right frontal lobe (newest part of the neocortex). It is through the rich interconnections of the amygdala, hippocampus and inferior temporal lobe that dreamlike states and visual and auditory hallucinations are experienced. Interestingly enough, the drug LSD disinhibits the amygdala and this gives rise to the vivid hallucinations which abusers of this hallucinogen experience.

The limbic system consists of a second important interrelated circuitry that involves the septal nuclei and the cingulate gyrus. These elements of the limbic system are primarily concerned with emotionally motivational features of stimuli and converge on the frontal lobes (newest part of the neocortex) to drive decision making and actions. It is through this circuitry that the controlling influences of religious belief systems and cultural cohesion are mediated.

The neocortex

The neocortex is the evolutionary newest development of the human brain (see figure 2 of the addendum). It is, once again, richly connected with the limbic system and brain stem and should be viewed as a natural, structural and functional extension of these former/older parts of the brain. The neocortex receives various inputs from the limbic system, notably the amygdala–hippocampus formation through the temporal lobe; motor cortex activation through the thalamus; other primary cortices such as the visual, auditory, sensory cortices via the thalamus; and direct associations with the frontal lobes via the cingulate (motivational aspects of the limbic system). In addition, the neocortex receives abundant input from the brain stem and cerebellum.

It is therefore useful to understand that everything is connected, that every part of the brain has developed systematically through a functionally driven process and that two evolutionary related (and usually anatomically adjacent) structures often share similar functions although they differ in the sophistication of their computations.

The neocortex is often called the rational cortex and is the part of the brain where rational/logical processes to analyse incoming stimuli from the external environment take place. Most of the cortex is used to build a non-emotional and objective representation of the external world, which is accomplished by differential extraction of stimuli through the different senses. These complex stimuli are analysed through a process of feature extraction and feature integration until the complex external stimuli have been reconstructed into an equally complex internal representation. This information is presented to the frontal lobes where consciousness resides, where decision making takes place, and where the execution of motor responses and actions are controlled. It is therefore through the neocortex that we think about things; construct ideas; and create solutions to problems of a spatial (three-dimensional), temporal (time-dependent) and logical nature. Note again that the different inputs from various parts of the limbic system, brain stem and cerebellum have influential control over the neocortex by providing the framework (cultural belief system) within which rational thoughts consciously operate.

Further descriptions of the neocortex fall outside the scope of this paper.

Studying the "neuroscience of religion"

Initial studies of brain behaviour involved observations of dysfunction in patients with neurobehavioral illnesses or trauma. These studies' deductions constituted most of our understanding of basic neuroscience. An example is the observations of the religious and mystical experiences of patients with temporal lobe epilepsy (a specific form of epilepsy that often involves hyperactivation of the amygdala–hippocampus complex).

Studies of the neurobehaviour of animals, especially through interventions but more often than not by cruel measures, contributed significantly to our understanding of the basic and more complex brain circuits and subsystems in the brain.

The advent of functional brain imaging brought a whole new dimension to the understanding of the workings of the human brain and will most likely shape the future way in which we see the way we think and feel. Functional magnetic resonance imaging (fMRI) is the most commonly used method today. Other commonly used methods include single photon emission computerised tomography (SPECT) and positron emission tomography (PET). Unfortunately, fMRI involves injecting dye into the vein of the person who is studied and he/she has to lie or sit enveloped by a huge machine. All these aspects differ from the real-life scenario and have to be acknowledged. Newer functional imaging techniques and the re-introduction of modified older techniques focus on user-friendliness and increased accuracy of real-life applicability.

The limbic system and religion have been studied largely through observational techniques and functional brain imaging (to a lesser extent); whereas the neocortex has more recently been studied by using functional brain imaging.

The limbic system and experiences of a religious nature

The hypothalamus–amygdala–hippocampus complex is intricately involved in the perception, facilitation and control of

- sexual experiences

- aggression
- hunger and thirst
- religious and mystical experiences

Mystical states can be achieved in concert with the inferior temporal lobe (Joseph 1996:283–286). It is believed that some parts of the limbic system are switched off through so-called de-afferentation and that the individual limbic nuclei (including the amygdala, hippocampus and temporal lobe) are hyperstimulated or activated (D'Aquili & Newberg 1999). In fact, it is well known that overstimulation of the amygdala and hippocampus can give rise to dream-like states, mystical experiences and out-of-body experiences. This is well described in terms of certain forms of temporal lobe epilepsy where activation of these limbic structures marks the onset of an epileptic attack.

The out-of-body experience

This describes the sensation of a person seeing himself/herself from outside his/her body, usually floating above his/her body in a euphoric state. If this is experienced around the time of imminent death, it is called a near-death experience.

A typical description follows:

> Betty L Experience 6/18/07: "I went to my friend's house for a facial. When I arrived, I was really stressed out. I did not think that I would be able to relax. A few minutes into the facial I became very relaxed. My body felt like it became very heavy. I felt like I was in a coma and was unable to move. I felt myself float upward. I then felt myself travelling toward the light. It was powerfully bright, yet soft. As I got closer to the 'end' of the light, I felt the presence of God and my grandfather who passed away 30 years ago. There was also an angel there that I was able to see. She is my guardian angel. The light was so welcoming, I could not wait to reach the source of it. I felt that if I got to that place, I would be permitted to stay."

It is known that the amygdala mediates emotional memories and processes of fear, love, pleasure, euphoria, etc. The hippocampus mediates visual-spatial, cognitive, verbal and recognition memory (Joseph 1996:280–286). To create a visual-spatial memory, the hippocampus has so-called place neurons, which are able to build a three-dimensional construct of an individual's position and movement in space. It is conceivable and the current notion that hyperactivation of the hippocampus has the ability to create a hallucinatory visual image in which the individual can see himself/herself from outside his/her body (Joseph 1996:233, 283). In addition, the concurrent hyperactivation of the amygdala produces a state of euphoria through release of opiates. The final construct takes place in concerted effort in the inferior temporal lobe. It is well documented that patients whose amygdala–hippocampus–temporal lobe has been electrically stimulated can report feelings of having left their bodies and floating against the ceiling, which account for an out-of-body experience.

The near-death experience

Many patients who faced imminent death and were even diagnosed as "clinically dead", but returned to life described a typical out-of-body experience. In addition to leaving their own bodies, they often encountered a dark tunnel that ended in a bright, radiant light where they would meet God or loved ones. During this experience they would often be in a calm, peaceful or euphoric state. It is interesting that these experiences were also described by the ancient Egyptians and Tibetans.

The experience of the radiating light is most likely related to visual projections to and from the visual cortex in the temporal lobe (which is in close proximity to the inferior temporal lobe) and to direct projections from the fovea in the eyes (concentrated retinal area that receives the majority of visual input). The presence and images of loved ones might indeed be mediated by the activation of the recognition memory images of the hippocampus and adjacent temporal lobe.

It is conceivable that the amygdala–hippocampus and inferior temporal lobe are differentially hyperactivated during the first phases of the dying brain. It also seems that the amygdala and hippocampus continue to fire after medical death and are the last part of the brain to die (Joseph 1996:286). If this is the case, it can eloquently describe the neural basis for a near death experience.

Although the neural mechanisms of the specific elements of the out-of-body and near-death experiences are somewhat empirical, the exact experiences can be induced by electrical stimulation of the amygdala–hippocampus complex and the inferior temporal lobe. These observations establish a neural basis for mystical states and near-death and out-of-body experiences, but do not lead to any conclusions about the existence or non-existence of the Transcendent. Indeed it is worth noting that these experiences can be non-adaptive from a Darwinian point of view, which makes it quite plausible that the non-physical can exist and provides a non-evolutionary/non-adaptive basis for belief in the spiritual and the transcendence after death through a near-death experience.

Religion, sex, aggression, hunger and thirst

As noted previously, the newer amygdala is closely associated to the older hypothalamus through its rich connections and proximity. These two limbic structures can act as a pair in a highly coordinated fashion in response to intensely emotionally motivated needs or stimuli. These include the need for sex, rage responses, and the need for food and water. Indeed the hypothalamus and the amygdala act in

tandem to mediate powerful motivational responses that are related to the sexual, aggression, and the need for food and water. Through their temporal connections via the hippocampus and connections with the right frontal lobe (neocortex), the hypothalamus and amygdala can for example simultaneously view a banana as food and as an object with sexual connotations. In addition, these same structures are intimately involved in religious experience and mystical experiences. It therefore seems that stimuli and response that are related to sex, aggression, hunger and thirst are all mediated by the same neural circuitry of the hypothalamus–amygdala–hippocampus–temporal lobe–frontal lobe complex.

It is worth noting that intensely emotionally motivated needs are infused into various religious practices. In this regard, female sexuality and fertility, sexual morality, fertility of the soil, water from the heavens, exclusion from other religious groups and other tribes/nations – often by means of acts of aggression and so-called holy wars – are an intricate part of most religious practices. By the same token, sexual acts and thoughts that are often enveloped in mystical sacredness and acts of aggression and other limbic needs such as food and water can be accompanied by prominent mystical and religious motivation. The notion that the same limbic neural circuits can co-activate various limbic needs such as sexuality, food, thirst, rage and aggression in religious beliefs and practices does indeed seem plausible and has a logical neuroscientific basis.

Whether the limbic system (through its intense emotionally motivated needs for survival) gave rise to mystical experiences, religion and the concept of gods and the spiritual as a means to gain control over the unknown or unknowable is not known or proven and at best speculative. It is also unproven and uncertain that co-activation of other intense emotionally motivated needs falsely informed and infused religious beliefs or served as non-accurate descriptions of the Transcendent or misinformed perceived revelations of the Transcendent.

The rational/cognitive system and religion

As stated previously, the neocortex is a logical evolutionary extension of the limbic system and older parts of the human brain. Some of the main concerns of the neocortex are:

- constructing an internal representation of the external environment (spatial features)
- constructing an internal representation of the self and its relation to the world (self-image)
- determining the causality of events and predictions of the future by using memory banks, imagery and logical deductive reasoning (temporal features)
- developing social bonding to promote survival of the human being as part of a group
- constructing novel solutions for problems and answers to questions (creativity)

The construction of an internal representation of the external environment forms the basis of the human brain's concept of reality and "what is real" – the term "seeing is believing" is probably correct in the sense that "seeing" is the neurological perception of the internal representation of the truth (the external environment) and remains a reflection of the truth at best. The same principle applies to the concept of "self-image". It is interesting to note that anorexia nervosa is a disease that is characterised by an altered self-image. The patient has an abnormal image of his/her body; "seeing" it as being overweight even though it might already be in anorexic state. It is the same neural processes that give the human brain the ability to build constructs of religious symbols and religious images of the Transcendent and of the life hereafter. The construction of symbols and images of rational nature (as opposed to the imaginary states that are mediated in the limbic system) takes place in the parietal lobes (these connect the occipital: visual brain at the back of the brain, temporal lobes and frontal lobes with each other)

Note that these neural processes also equip the human brain to construct temporal sequences of events through memory banks, logical and deductive reasoning, and the neural state of consciousness. The latter probably resides in the prefrontal cortex (front part of the frontal cortex, where planning takes place). The construction and conscious participation in rituals and rites that are filled with symbols, symbolic meanings and thoughts about the "life hereafter" depend heavily upon the mentioned structures of the neocortex.

The development of social bonding most likely co-evolved with the development of faculties that facilitate communication, such as language and music. The adaptive value of social bonding, (promoting survival of the group and the survival of individuals who belong to the group) seems above doubt. To belong to a group requires social commitment and subjective commitment to social norms. The prefrontal cortex seems to be instrumental in the development of such social commitments and bonding.

It is interesting to note that the individual has an irrational tendency to so-called moralistic aggression (Rossano 2006) and will allow harsh punishment of individuals who threaten the group integrity. This behaviour is also often seen in religious practices, sensibly so since religious belief is at least a strong mediator of social cohesion.

Thus the rational mind/neocortex mediates especially the cognitive beliefs, religious consciousness and social bonding of religion.

Is there a "God-spot" in the brain?

The question often arises as to whether there is a single neural circuit or neural circuitry that is dedicated to thoughts, perceptions and experiences about a God. Kapogiannis and Grafman recently performed a study of the neural substrates/correlations of specific thoughts and beliefs about God (Kapogiannis & Grafman 2009). The subjects of the study, for example, had to think about God as being a loving/punishing deity. These are all thoughts/beliefs that are often encountered by human beings. These thoughts were studied by using fMRI. The study concluded that religious thoughts/beliefs about God make use of conventional neural circuitry. This means that if we accept the study to be a true reflection of reality, there probably is no "God spot" in the brain; instead thoughts and feelings about God are mediated by the conventional/"generic" brain circuits that are also used for other but similar neural processes.

Selective cortical lesions enhance self-transcendence

As an introduction to thinking about the role of the neocortex in transcendence, it is worth noting a study that was recently published (Skrap & Fabbro 2010). Researchers performed neurosurgery on a number of patients who had brain tumours in the parietal regions of their brains. The parietal cortex constitutes the connecting region of the neocortex between the frontal, occipital and temporal regions. Surgery in each patient had lead to some degree of lesional damage to the right or left inferior parietal cortex. It was consistent with an increased ability to self-transcend. The definitions of "self-transcendence" that the researchers used are: *"*A stable personality trait measuring predisposition to spirituality and *"* Self-transcendence reflects a decreased sense of self and an ability to identify one's self as an integral part of the universe as a whole" (Skrap & Fabbro 2010). The study suggests that the parietal lobe plays an important role in the modulation of self-transcendence properties and that dysfunctional parietal neural circuitry might predispose the brain to altered altruistic spiritual awareness.

It has to be understood that many integrative neocortical functions use the same basic circuitry in a so-called temporal–parietal–frontal pathway that converges on the prefrontal cortex for cognitive understanding and functioning. It is the selective dysfunctional state of the parietal aspects of the temporal–parietal–frontal pathway that presumably enables the patients to reach self-transcendental states.

It is conceivable, although possibly oversimplified, that the neocortex has to be silenced in an active and conscious manner to enable the limbic system (through the amygdala–hippocampus–temporal lobe system) to reach a spiritual state. In this regard, "silencing the mind" during meditative processes might well be a process whereby silencing and detachment from active neocortical/rational brain pathways render differential activation and de-afferentation (a form of neural feedback inhibition) of the limbic structures capable of inducing mystical and spiritual states.

Putting it together

The human brain has evolved purposefully to ensure survival. The oldest part of the brain is the brain stem, which continuously scans the inner state of the body, modulates conditions in every organ for optimal function and maintains the vital rhythms that are essential for life. The hypothalamus can, in some ways, be regarded as the newest part of the brain stem and the oldest part of the limbic system; it performs on a rudimentary level and evokes powerful emotional experiences in relation to hunger, thirst, sex, rage and religious/mystical experiences. Together with the amygdala, it activates two important neural circuits in relation to these experiences:

1. The hypothalamus–amygdala–hippocampus–inferior temporal lobe for euphoric, mystical and religious experiences that sometimes consist of altered spatial states such as out-of-body experiences.

2. The hypothalamus–amygdala–cingulate–prefrontal cortex for emotionally motivational drive. This drive is controlled by the individual's religious and cultural belief system.

The limbic system can therefore be seen as being responsible for the emotional and mystical experiences of religion and as the controller of religious-inspired or religious-influenced actions through its motivational drive on the prefrontal cortex.

The neocortex, in contrast, is the rational mind where thoughts and beliefs are entertained and analysed. Through the extraction and integration of different contributions of spatial and temporal information (mainly through the temporal–parietal–frontal neural circuits), the product of various neural computations converge upon the prefrontal cortex in the frontal lobe where consciousness resides and where decisions, actions and creative solutions are derived. The co-convergence of the emotional–motivational inputs from the hypothalamus–amygdala–cingulate–prefrontal cortex circuit ensure that all the prefrontal outputs, including conscious beliefs, are under the influential control of the individual's limbic religious belief system and social commitment to the group.

The thoughts and beliefs about God and the experiences that relate to religion and spirituality use the same conventional neural circuitry as other thought processes and experiences of a non-religious nature. Although we lack more scientific evidence, it is plausible that transcendence is partly dependent on neocortical inhibition (such as seen in lesions of the inferior parietal cortex). This is supported by the practice of meditation and contemplation during which the mind has to be "silent", which implies a form of neocortical control and conceivably some form of neocortical inhibition.

Neocortical inhibition might be the trigger for the activation of the amygdala–hippocampus–inferior temporal complex. Whether or not transcendence will follow might in turn depend on the degree of differential activation and de-afferentation of the amygdala–hippocampus–temporal complex.

It is worthwhile to remember that the brain and its circuitry are intimately connected and that neuroscience tends to oversimplify understanding the brain's function through dividing the brain into comprehensible systems and subsystems. This is not how the brain functions; in reality it functions as a holistic unit. Feelings, thoughts, beliefs and experiences are therefore simultaneously experienced and activated; they inform each other and modulate the underlying circuitry considerably.

We have to acknowledge that our best observations can only be reflections of existing reality or at least of what we perceive to be real. The neural substrates and circuitry that are used to perceive the spiritual and the Transcendent are not unique in function and dedication; however, this does not prove the non-existence or existence of God. Indeed the best neuroscientific methodology at present can only cast light on our insights on how we transcend; it cannot shed light on the Transcendent or the possible source of religion and religious experiences.

Finally, it should be noted that the non-uniqueness of the neural circuitry that is used to mediate religious experiences can lead to possible infusions of non-religious experiences that share the same circuitry (such as aggression, hunger, thirst and sex) and can influence, and even cloud, religious beliefs.

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Addendum

Figure 1: The limbic system

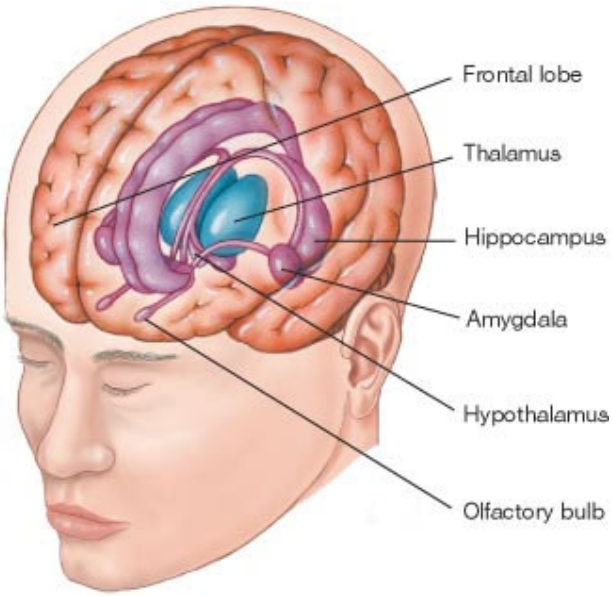
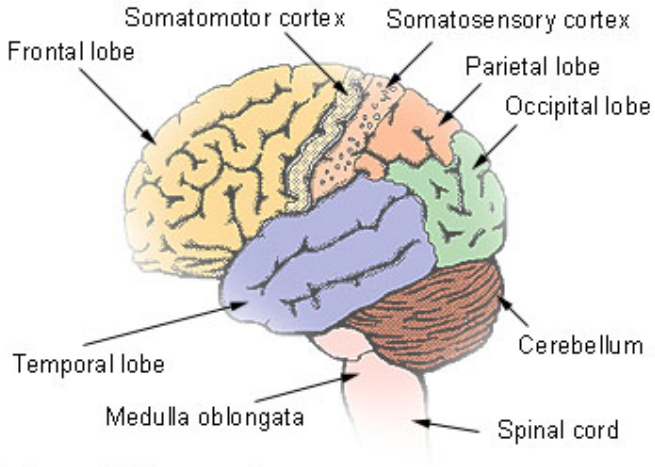

Frontal lobe
Thalamus
Hippocampus
Amygdala
Hypothalamus
Olfactory bulb

Figure 2: The neocortex



Lobes of the cerebrum