

Spirituality, Religiousness and the Brain

Hernando Vargas-Uricoechea^{1*} and Ernesto Barceló-Martínez²

¹*Director of the Metabolic Diseases Study Group, Associate Professor of the Department of Internal Medicine, Universidad del Cauca, Popayán, Colombia*

²*Research Teacher, Faculty of Psychology, Universidad de la Costa, Scientific Director, Leader of the International Neuroconductive Investigation Group, Colombian Institute of Neuropedagogy, Barranquilla, Colombia*

***Corresponding Author:** Hernando Vargas-Uricoechea, Director of the Metabolic Diseases Study Group, Associate Professor of the Department of Internal Medicine, Universidad del Cauca, Popayán, Colombia.

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Abstract

Spirituality and religiosity are concepts that have accompanied the human being since the beginning of time, defining both concepts is difficult, however, medical research has increasingly made it possible to deepen and refine their definitions, as well as trying to find the link between them and different health conditions. Recently, a significant number of studies have also evaluated the brain areas involved in both spirituality and religiosity. Such studies are described and discussed in this article.

Keywords: *Spirituality; Religiousness; Brain; Mystical*

Introduction

For decades an attempt has been made to specifically distinguish between spirituality and religiousness, particularly because in the end, all religions try to promote spirituality through their principles, giving rise to a significant confusion in the understanding of both concepts. However, these definitions are not necessarily mutually exclusive and clearly may overlap. One of the many definitions of spirituality has characterized it as the essence of the individual, or the search for a meaning and a purpose in life. Religiousness in contrast, may also be understood as one of the dimensions of spirituality and refers to the extent to which an individual believes in, follows, and practices a religion [1-4].

Assessing or measuring spirituality and religiousness is a complex endeavor, regardless of the setting (clinical, social, theological, inter alia), especially if the instruments used to measure both concepts overlook the potentially beneficial or harmful effects that religious and/or spiritual intervention may bring about to people. Although there are a number of scales or measurements to assess spirituality and religiousness, the psychometric characteristics of such tests are still weak and unreliable. For this reason, there is a growing development of imaging studies aimed at identifying the areas of the brain associated with spirituality and religiousness [5-9].

Certain areas in the frontal and parietal lobes have been identified as the primary sites of significant neuronal activity in highly spiritual and/or religious individuals, or in those who have lived through mystical experiences (a mystical experience is a state of mind in which the mortal sense of "self" merges with the Divine) [10-12].

This review is intended to describe and analyze the studies that have assessed the areas of the brain that are involved with spirituality, religiousness, and mystical experiences of the human being.

Generalities and definitions of spirituality, religiousness and mystical experience

Religion and spirituality have been part of human experience since the origins of mankind. Multiple definitions have been given, but the most contemporary concepts have defined religiousness as a system of beliefs, spiritual practices (or both), organized around the worship of a Deity or a number of Deities, including behaviors such as prayers, meditation, and participation in public rituals. These feelings, thoughts, and experiences arise in the quest for what is sacred and is understood as the group of institutions that prescribe, organize, or coordinate the armamentarium of theories, doctrines, dogmas, rules, symbols, celebrations, etc., around a transcendental belief [13,14].

Some authors have divided the concept of religiousness into two parts: intrinsic religiousness, principally characterized by the interiorization of religious beliefs, involving praying as an important manifestation; and extrinsic religiousness, that refers to the observance of the religious rules *per se*. Based on this concept, intrinsic religiousness refers to spirituality in the strict sense; this assumption could explain why the two concepts overlap, since the essence in both is the relationship to a Divinity, regardless of which [15-18].

On the other hand, the term Spirit is etymologically derived from the Hebrew word *Ruah*, from the Latin word *Spiritus*, or from the Greek *Pneuma*, which means “breath of air or breath of life”. The word spirituality derives from western Christianity “*Spiritualis*” which is a translation of the Greek word “*Pneumatikos*” which translates into “relating to the realm of the spirit”; in other words, living from the Spirit or from the source of the Spirit. A myriad of definitions of spirituality have been suggested over time, including broad and varied concepts such as: the relationship with God or with a spiritual being; something superior to oneself; transcendence (transcendental); meanings and purposes of life itself; a person’s vital force; inner life; inner peace; communion with others; inter alia [19-21].

For some authors, spirituality is considered to be one of the elements of personality and is defined as an innate motivation that guides behavior, aimed at building a deeper sense of purpose in life, as well as the multidimensional ability to search for the meaning and connection in the relationships with oneself, with other people, with nature, with that which is sacred [22,23].

According to both definitions - religiousness and spirituality - it is then clear that both concepts may overlap (Figure 1).

Finally, a mystical experience (in the Christian sense) is characterized by a sense of unity with God, though it may also include a number of other elements such as the feeling of having touched the last frontier of reality, the experience of atemporality and absence of space, the feeling of being a unity with mankind and the universe, in addition to positive feelings of affection, peace, joy and unconditional love [24,25].

Areas of the brain involved in spirituality and religiousness

Numerous structures and neuronal systems have been involved with the concept of spirituality (in religious and in non-religious settings, and in mystical experiences). Researchers have appraised the immediate physiological changes in the brain, and the neurophysiological effects of prayer, guided by religious practices, beliefs, mystical experiences, and ordinary religious practices; all of these have been monitored through the regional brain activity, the activity of neurotransmitters, and of the cerebral blood flow. The physical representations of these biological processes have been described using the encephalogram (EEG), the positron emission tomography (PET-SCAN), and the functional magnetic resonance images (fMRI) [26,27].

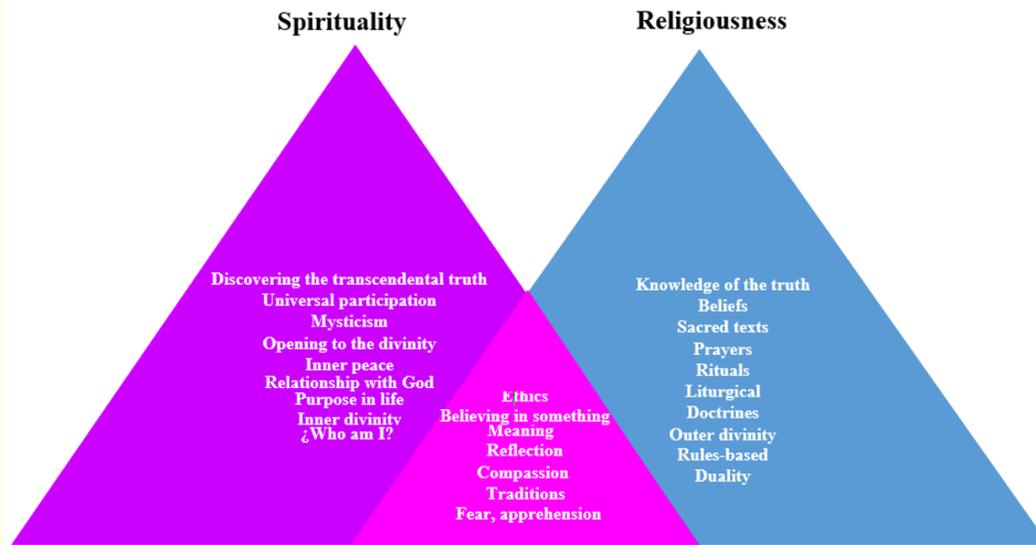


Figure 1: Illustrates the hypothetical relationship between spirituality (left triangle) and religiousness (right triangle). The two terms partially overlap (middle triangle) with separate conceptual areas which are not shared with the other.

A large proportion of the studies have been conducted in individuals with a very high Divine or Sacred affiliation, (priests, nuns, etc.) or in individuals who constantly and regularly practice praying and meditation. One study was intended to identify the neural correlations of a mystical experience among contemplative Carmelite nuns (n = 15), using fMRI brain images. The study found areas of significant activation in the right medial orbitofrontal cortex [Brodmann’s area (BA) 11], in the right and left medial temporal cortex (BA 21), in the right and left inferior parietal lobes (IPL) (BA 40 and BA 7, respectively), in the right and left caudate lobes, in the left medial prefrontal cortex (BA 10 and 11), in the left dorsal anterior cingulate cortex (BA 32), the left insula (BA 13), the left encephalic trunk, and the left putamen [28].

Another study also conducted in Carmelite nuns (n = 14), evaluated the neuro-electrical correlation of the mystical experiences using spectral EEG and correlation or coherence of the EEG, during such experience. The EEG activity was recorded in 19 sites of the scalp at rest, one control condition, and one mystical experience. During the mystical experience (in contrast with the control condition) the leads showed higher theta power in F3, C3, P3, Fz, Cz and Pz, and a stronger gamma-1 power was identified in T4 and P4. Stronger delta/beta, theta/alfa and theta/beta relationships were found in various lead locations. Moreover, the pair of FP1-C3 leads showed stronger coherence for the theta band, while the F4-P4, F4-T6, F8-T6 and C4-P4 pairs of electrodes showed higher coherence for the alpha band. The changes that took place during the mystical experience were associated with rises in the theta potentials over some areas of the frontal lobe (central and left region), and in the parietal lobes; the gamma-1 power increased in the right temporal lobe and in the parietal lobes. Additionally, there was an increase in the theta connectivity between the central and left frontal area, as well as in the enhancement in the long-distance alfa connectivity in the right hemisphere (between the temporal, right frontal and parietal regions, and between the right central region and the parietal region) during the mystical experiences [29].

Furthermore, the debate about the correlations among the different areas of the brain and religious beliefs and mystical experiences, has been driven by other studies that have provided a deeper understanding of the cerebral mechanisms involved in religion. Therefore,

as a result of the observation that certain areas of the brain involved in social cognition are recruited during prayer, the role of “hypermentalizing” has been analyzed, as a cognitive bias predisposing people to become religious. There is also the idea that the downregulation of the prefrontal cortex may be associated with the acceptance of religious ideas. In accordance with this suggestion, patients with damaged orbitofrontal cortex (OFC) have been found to exhibit a higher probability of having mystical experiences [30,31].

For example, the primary purpose of one study was to establish the relationship between religiousness and different brain structures; the authors’ hypotheses were: (a) a greater acceptance of general religious beliefs is associated with a reduced volume of the bilateral orbitofrontal cortex; (b) a higher prevalence of mystical experiences is associated with a reduced volume of the right middle temporal gyrus and the hippocampus; and (c) a higher prevalence of religious beliefs and mystical experiences is associated with volume changes in both IPLs. A confirmatory morphometric analysis was conducted to prove the three hypothesis. When analyzing the regions of interest, no proof was found that religiousness was associated to a decreased orbitofrontal cortex volume or to changes in the structure of both IPLs. Neither was it shown that the mystical experiences were associated with a reduction in volume of the hippocampus, the right medial temporal gyrus, or with the IPLs. No differences were found in the different brain structures, in association with religiousness and mystical experiences [32].

On the other hand, it is thought that self-transcendence is a trait characteristic of the human personality, which is associated with the experience of the spiritual aspects of the being. Based on this idea, a study assessed the existing relationship between self-transcendence and the availability of serotonin transporter (SERT) in the raphe nuclei of the encephalic trunk (these nuclei are sets of five different serotonergic nuclei with rostro-caudal extension), through ultra-high resolution MRI images and PET-CT with $[(11) \text{C}]$ DASB. The purpose of the study was to assess the serotonergic neuronal activities in healthy individuals. The regions of interest included the dorsal raphe nucleus (R1), the median raphe nucleus (R2), the raphe pontis (R3) and the caudal raphe nuclei (R4 and R5) localized in the brain stem. To estimate the availability of SERT, the binding potential (BP) was obtained using a simplified reference tissue model (SRTM2). Additionally, the “temperament and character inventory was administered, to measure self-transcendence. The study found that the total self-transcendence score has a significantly negative correlation with $[(11) \text{C}]$ DASB BP in the caudal raphe (R5). The score for the evaluation of spiritual acceptance (as part of the applied inventory), was significantly and negatively correlated with $[(11) \text{C}]$ DASB PDU in the median raphe nucleus (R2) [33].

Another study assessed the probable specific cerebral substrates for religious and spiritual euphoria in devout Mormons ($n = 19$), using fMRI. The neurobiological substrates of the religious experiences were measured, and several stimulation paradigms were used to generate that spiritual and religious feeling, using personalized ecological stimuli for the religious Mormon experiences. In this study, a central recognizable feeling for the devotional practice of the participants was associated in a reproducible manner with the activation of the frontal lobe regions associated with attention and motivation. The activation of the nucleus accumbens preceded the spiritual feelings by 1 - 3 seconds, and the activation of attention in the anterior cingulate and the frontal visual fields was stronger in the right hemisphere [34].

Similarly, a reduction in the risk of major depression has been reported in the descendants of individuals with such disorder, and who reported that religion or spirituality were very important to them. Based on this idea, a study assessed in 103 adults, descendants of the second or third generation of family members with depression (high familial risk), or without depression (low familial risk), or in first generation descendants, the importance they gave to religious and spiritual matters, and going to church. The study measured the thickness of the cerebral cortex using fMRI and found that the high-risk adults who stated the high importance to them of religious and spiritual life, had a thicker cerebral cortex as compared to those who said that it was of little importance. The importance of religion or spirituality was associated with thicker cerebral cortexes in the left and right parietal and occipital regions, the medial frontal lobe of the right

hemisphere, and the cuneus and precuneus of the left hemisphere (regardless of the familial risk). Moreover, the impact of this religious or spiritual importance on the cortical thickness was significantly stronger in the high-risk group, than in the low risk, particularly along the medial wall of the left hemisphere [35].

Moreover, it has been shown that religious experiences may be considered a preconceptual feeling and could predict the activation of certain areas of the limbic region (involved with emotions); therefore, the attribution theory could predict the activation of areas of the brain that mediate reasoning [36].

Based on this assumption, a study assessed a group of subjects who identified themselves as religious persons and attributed their religious experiences to the biblical psalms; the objective was to explore the areas of the brain involved with religious experiences. In this study, PET images showed a specific and significant activation of the right dorsolateral prefrontal cortex, of the frontal dorsomedial cortex, and of the parietal medial cortex in religious subjects during their religious experience (as compared to non-religious individuals). During this experience, the religious subjects showed few additional activations, including the dorsomedial frontal cortex and the right precuneus. These activations involved areas that have been associated with cognitive processes, while the limbic areas (including the amygdala and the orbitofrontal cortex) upregulated by emotional stimuli did not show any changes. For the religious individuals participating in this study, the biblical Psalm 23 was the most significant religious signal [37].

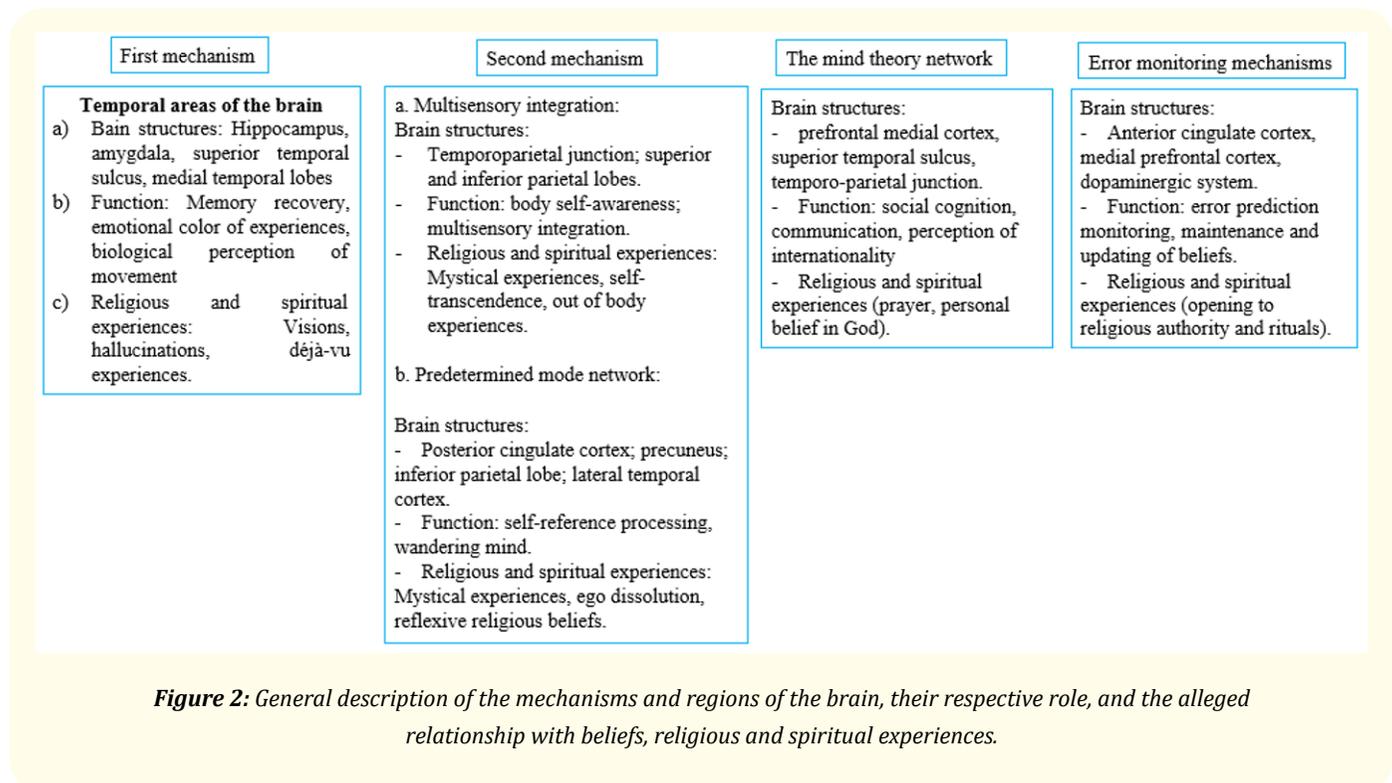
The typical predisposition of the human being to spiritual feelings, thoughts and behaviors is measured by a presumably stable personality trait called self-transcendence. Some neuroimaging studies suggest that the neuronal activation at the fronto-parietal-temporal level may be associated with a significant range of spiritual experiences, although the causal link between those areas of the brain and spirituality is not well established. However, the personality assessment, before and after neurosurgical procedures, using advanced mapping techniques of the brain lesions, has found that the selective damage of the parietal inferior-posterior bilateral regions was associated with a specific increase in self-transcendence. Hence, any changes in the neuronal activity in those areas could lead to unusually fast modulation of a stable personality trait (self-transcendence) [38,39].

According to this idea, a study combining the analysis of different scores of self-transcendence, measured before and after surgery in patients with brain gliomas, or meningiomas, assessed the potential changes in self-transcendence, induced by specific brain lesions, and the causal role of the frontal and temporoparietal structures, in addition to the inter-individual differences. The findings showed that the removal of high- and low-grade gliomas affecting the posterior areas of the brain, led to a specific, significant and reliable increase in self-transcendence (though this was not the case in individuals with meningiomas). These changes were observed shortly after the cortical ablation. Patients with posterior and relapsing gliomas, exhibited higher ratings of self-transcendence (in contrast to patients with anterior gliomas, both before and after surgery). Post-surgical changes on self-transcendence, also involved the three subscales that are part of self-transcendence: creative oblivion of self (self-forgetful), transpersonal identification, and spiritual acceptance), indicating that cortical injury of both posterior parietal lobes may increase self-transcendence [40].

Integration of brain mechanisms into spirituality and religiousness

The past three decades have been key for the establishment of some biological and neurocognitive foundations of spirituality and religion. Through the use of neuroimaging techniques, brain stimulation studies and a few neuropsychological studies, the knowledge about the areas of the brain and the circuits involved in spirituality and religiousness has expanded significantly, hence providing a more global vision of the most important mechanisms underlying supernatural beliefs and experiences. However, many findings reported in the literature seem to be contradictory, lack proper methods and analyses, and the results are not conclusive. Moreover, there isn't an "integrative" framework that unifies the different findings reported in the literature. Consequently, some "integrative" models have been recently suggested, with regards to the neurocognitive basis of spirituality and religiousness [41].

For example, based on concepts derived from predictive processing, a number of models have been suggested in which religious beliefs and experiences are directly associated with a differential appraisal of the interoceptive and exteroceptive information. Four neurocognitive mechanisms are identified in these models (with empirical evidence), which to a certain extent, explain the specific religious beliefs and experiences. The first mechanism describes the role of the temporal cortex of the limbic system in religious experiences in self-transcendence emotions (Figure 2). The second mechanism describes how the areas of the brain that accept multisensory integration and the default mode network (DMN) are involved in spiritual and transcendental experiences. The third mechanism describes how the so called “Theory of Mind” (ToM) may play a role in personal experiences about God. The fourth mechanism focuses on describing the role of the “top-down” processes, in other words, the expectations, the inhibition mechanisms, and the prediction of error monitoring in religious beliefs and experiences [42-44].



Discussion

The results of the trials herein discussed suggest that there are several regions and systems in the brain that mediate various aspects of mystical experiences, and that such experiences are complex and multidimensional (which points to the involvement of some changes in perception, cognition and emotion). This suggests that several cortical areas of both cerebral hemispheres are involved in these experiences. The search for the neuronal correlates of the beliefs and mystical (or religious) experiences, should probably be changed from an approach based on the structural differences of the brain, to a functional and multivariate approach. When evaluating the results of self-transcendence, it is associated with the availability of SERT in specific sub-nuclei of the raphe, which suggests that the serotonergic system may be an important biological basis for human self-transcendence. According to the connections of these nuclei with the autonomous cortico-limbic and visceral structures, the functional activity of these nuclei and their associated neuronal circuits, could play a specific and crucial role in the manifestation of self-transcendence.

Similarly, according to the Mormon religious tradition, spiritual and religious practice is based on prayer, study of the Scriptures, audio-visual musical performances, and teaching of religious topics by the leaders of the church (and the study of the teachings of the religious authorities). The association of abstract ideas and of the brain reward circuitry, may then interact with attention and emotion processing, suggesting a mechanism whereby “doctrine” concepts may be intrinsically gratifying and could drive the behavior of religious individuals. Although multiple regions of the brain may contribute to spirituality, the parietal cortex and its connecting networks to other structures, are probably the most involved neuronal circuits. Therefore, it could be said that religious experiences may be a cognitive process mediated by a pre-established neural circuit, which involves the prefrontal dorsolateral cortex, the dorsomedial frontal cortex and the parietal medial cortex. Due to the fact that religious attributions take place under anomalous or ambiguous situations, when the individual does not know what to expect or what to do, but actively and persistently looks for a solution, a persistent, internally generated “disposition” arises, which subsequently reactivates the religious mindset in the presence of salient religious signals.

Another finding showed that the more significant religion or spirituality is for an individual, the thicker the brain cortex; this could account for a stronger resistance to the development of depression in those individuals with a family history that increases the risk of depression, probably by expanding a cortical reserve, that to a certain extent offsets the vulnerability to developing familial depressive disease because of cortical thinning.

The parietal lobes have been considered the area of the brain that concentrates most of the spiritual and religious burden and mystical experiences. So, the spiritual perceptions and mystical experiences of priests show associations and functional activations of the parietal cortex. Neuroimaging studies conducted in individuals who practice meditation praying, suggest an inverse relationship between the activity of the parietal lobe and religious/spiritual beliefs. The excitatory stimulation of the IPL has been associated with a reduction of the religious and spiritual aspects; in contrast, any IPL injury apparently results in increased spirituality and religiousness. There has been recent evidence showing some rapid changes in religiousness/spirituality in healthy individuals undergoing non-invasive stimulation procedures with repetitive transcranial magnetic stimulation (rTMS), in order to interfere with the neuronal activity in the dorsolateral prefrontal cortex (DLPFC) and in the IPL, in a reversible manner. Specifically, the interference with the neuronal activity of the IPL was reflected in an increase of the automatic self-representation of religiousness/spirituality of the participants, while no changes were present in other self-representations unrelated with religiousness/spirituality; for instance, self-esteem. Theta stimulation (in bursts) studies on the right IPL, contributed with additional evidence that the modulation of cortical excitability of the right IPL, induces rapid changes in the self-concepts related to religiousness/spirituality; these results could prove the causal role of the right IPL in mediating the typical changes from neuroplasticity on religiousness/spirituality [45-47].

When considering a theoretical basis to explain why the parietal cortex has been repeatedly involved with studies in spirituality, it is important to consider its function from a broader perspective. The parietal cortex contributes to multiple processes, including attention, impulse control, planned reasoning, sensory processing, and spatial reasoning, inter alia. Curiously enough, since spirituality involves a felt sense of connection with someone or something outside oneself, the parietal cortex - and particularly the right hemisphere - has been identified to contribute to a sense of self. For instance, it has been said that the medial/precuneal parietal cortex, as part of a medial paralimbic network involving cingulate prefrontal and medial anterior regions, represents an important area as “neural signature” of self-consciousness. Additionally, this medial parietal region seems to be functionally connected to the lateral regions of the parietal cortex. Consequently, a key component of spirituality may involve the IPL and related circuitry. Other studies have assessed the spiritual condition in contrast to stress and have shown decreased activation of the medial thalamus and of the corpus striatum, regions that have also shown increased activity following stress signals, as compared to relaxation conditions (neutral). These regions are involved in sensory and emotional processing and represent components of an identified cortical-striatal circuit, associated with stress response, through which the thalamus transmits information to the striatal regions. The reduced activity in these regions suggests then that the spiritual experiences may differ - much like any stress-triggering experiences -, in their upregulation of these subcortical regions.

Conclusion

1. Religiousness is a system of beliefs, spiritual practices, or both, organized around worship of an almighty Deity or Deities.
2. Spirituality is the multidimensional ability to search for the meaning and connection of the relationships with oneself, with other people, with nature, and with what is sacred.
3. A mystical experience is a sense of unity with God, a sense of unity with mankind, with the universe, peace, joy, and unconditional love.
4. Certain areas in the brain have been involved with the concept of spirituality, religiousness, and mystical experiences, particularly the inferior parietal lobes.

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