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CHAPTER 17

Neuroscience and Religion: Surveying the Field

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Scientific and religious communities have long been at odds over scientific attempts to explain religious experience. Since the beginning of the modern era, a number of scientists interested in religion and spirituality have sought a rigorous understanding of how these types of experiences manifest themselves in the brain and in human behavior. According to this view, our deepest beliefs and most elevating experiences can be understood in scientific terms—in particular, in terms of neuroscience studying "brain anatomy, brain function, and brain chemistry" (Tiger and McGuire 2010, 113). Yet others doubt that science has a legitimate role in exploring the nature of religion or spirituality. From their perspective, scientists should not attempt to explain the ineffable at all, and they regard such efforts as a challenge to the values and experiences that they consider most personal and sacred.

Aldous Huxley, one of the most prophetic science fiction authors of his generation, wrote in 1958, "That men and women can, by physical and chemical means, transcend themselves in a genuinely spiritual way… seems rather shocking. But, after all, the drug or the physical exercise is not the cause of the spiritual experience; it is only its occasion." As a seasoned explorer of the boundary between chemistry and spirituality, Huxley believed that the "chemical means" of spiritual experience do not invalidate the psychological value of the state itself. In that case, efforts to better understand those means is especially important for the scientific study of those experiences.

It should be possible to undertake a scientific approach to religious and spiritual experience without reducing those experiences strictly to chemical reactions. And even if such reductionism were possible, other disciplines would likely still provide a valuable grammar for describing and understanding various aspects of religion and spirituality. At the same time, any social, cultural, or personal conception of the divine or of a higher power

eventually comes down to what happens inside the brain (Newberg and d'Aquili 2000). The feeling of falling in love, pain from a broken bone, the beauty of a sunset—these and every other sensation we have ever had result from chemical reactions in the brain. Just as humans cannot see without eyes or hear without ears, neither can humans experience anything without the continuous molecular reactions that are happening in your brain right now—even as you read these words. So while neuroscience might not be sufficient to understand religion and spirituality in full, it is indeed necessary. This field of study is considered by some to be part of what has been referred to as *neurotheology*—the link between neuroscience and religious and spiritual investigation.

Additionally, there are some kinds of questions that empirical study might be unable to answer. Neuroscience can help us to address questions about the mechanics of the brain, but not about the underlying nature of reality or the accuracy of people's religious/spiritual beliefs. Metaphysical questions such as these fall to philosophy, theology, and, some would say, personal faith. Although some questions might remain mysteries, scientists can at least strive to explain certain causal aspects of religion and spirituality from a neuroscientific perspective, focusing on the neurochemical. For example, does having higher quantities of a certain chemical in the brain predispose people to become believers? How do meditation and prayer exert their beneficial effects on a chemical level? Are religious and spiritual experiences that are triggered by psychedelic drugs similar to or different from those that occur through meditation?

Each of these questions is addressed in the pages that follow, though no definitive answers have yet been reached. As we intend to show, when it comes to religion and spirituality (and even to the brain science behind them), the story is often much more complicated—and interesting—than it may seem at first glance. For example, although religious and spiritual beliefs are associated with certain differences in brain structure, it is usually not clear whether those findings indicate causation or just correlation—whether a different kind of brain tends to adopt certain kinds of beliefs, or whether certain kinds of beliefs change the structure of the brain.

This chapter will review religion and spirituality from the perspective of neuroscience. First, it will characterize religion and spirituality and describe how they can be understood through a neuroscientific approach. Next, it will review some of the basics of neuroscience, including methods of study and chemicals of particular importance to the nervous system. Lastly, it will review major findings in this area, highlighting those that might lead to breakthroughs in the near future. The goal of this chapter is to provide the reader with an understanding of why neuroscience matters for the scientific study of religion and spirituality.

THE SCIENTIFIC STUDY OF RELIGION AND SPIRITUALITY

The challenge of understanding neuroscience's relationship to religion and spirituality stems from the fact that these concepts are classically difficult to define. Some scholars believe it to be impossible (McKinnon 2002), while others have organized conferences to attempt consensus on working definitions of these concepts (Larson, Sawyers, and McCullough 1998). Without a doubt, part of the difficulty with defining these concepts comes from the wide range of components they encompass, including sacred texts, beliefs, community, rituals, and practices. Additionally, religion and spirituality overlap substantially, yet they also differ in important respects.

Religion has been described in a number of different ways (Zinnbauer et al. 1997). Philosopher and psychologist William James (1902) described religion such as believing in a god and trying to live in accordance with divine commandments. Émile Durkheim (1912) had a more social focus, defining religion as a moral community with shared beliefs at its core. More recently, Michael Argyle and Benjamin Beit-Hallahmi (1975) specified that religion includes beliefs about a supernatural entity and shared practices and rituals.

One might broadly define a religion as a system of beliefs about supernatural phenomena and practices intended to acknowledge or interact with them. Most common conceptions of religion reflect the worship of divine beings, be they literal entities or representations of abstract forces. These beliefs and practices are often maintained by social organizations, including facilities for worship and official councils of religious authority.

An increasing number of people in the United States identify themselves as spiritual but not religious (Zinnbauer et al. 1997). That is, they relate to the more subjective, experiential qualities that religion describes, without observing particular customs or belonging to a religious community (Forman 1998). Many such people espouse a belief in a "higher power" or some all-encompassing force that unifies humanity, living things, or even the entire universe.

Definitions of spirituality are, in general, more recent and broader (Zinnbauer et al. 1997). Frances Vaughan (1991) emphasizes the more individual and subjective connotations that spirituality holds in relation to religion. Charles Tart (1983) expands the concept of spirituality beyond the supernatural to include love, compassion, and purpose. Kenneth Pargament (1999) provides an often-used and inclusive definition of spirituality as a search for the sacred.

Both religion and spirituality involve beliefs of some kind. For the spiritually inclined, these beliefs might be intuitive rather than formal, as they might rely on subjective feelings, such as the feeling of oneness with the world, rather than on particular creeds of faith. For the religious, individual beliefs tend to align with a collective belief system—one that addresses such topics as the existence of a deity, the creation of the world, the relationship of consciousness to matter, and the purpose of existence.

Religion and spirituality also make use of *ritual*. Ritual involves separating from the structure of daily life, entering an intentional personal practice or group process, and then returning to daily life (Turner 1995). People who describe a personal relationship with the divine or the mystical also tend to either accept collections of traditions from their religious systems or practice their own ways of achieving these experiences (Luhrmann 2012). Religions promote rituals that are intended to evoke spiritual and related experiences, such as prayer and group ceremonies (Graham and Haidt 2010). Religious and spiritual people also use practices such as meditation, prayer, or the use of psychedelic drugs, to access *altered states of consciousness* (Hood, Hill, and Spilka 2009).

Religious experiences and spiritual experiences are often referred to under the umbrella term *religious, spiritual, and mystical experiences* (*RSMEs*) (Beauregard 2011). These experiences usually include positive feelings and may involve a diminishment of the sense of self, a feeling of unity, a sense of sacredness, and a deep feeling of personal meaning (Hood et al. 2001). Empirical research has demonstrated that such experiences can be positively transformative in their effects on well-being and altruistic behavior (Griffiths et al. 2006; 2008) and those effects can sometimes even last decades (Doblin 1991). Recently, a

Beatific vision illustration for Dante Alighieri's* Paradiso *(part of the* Divine Comedy*), by French artist and illustrator Gustave Doré (1832–1883). *Scientists and religious scholars have classified the most common kinds of religious and spiritual experiences into categories that include mystical experiences, involving a sense of connectedness or unity with all things; numinous experiences, encounters with a god or some other abstract spiritual entity; and calling experiences, entailing profoundly meaningful, temporary mental states that include a revelation or directive.* **KEN WELSH/DESIGN PICS/CORBIS.**

number of academics ranging from skeptics to believers have come forward to describe their own experiences of feeling "called" to their current profession (Yaden, McCall, and Ellens 2015).

In the *Varieties of Religious Experience* (1902), William James describes a number of RSMEs through first person accounts of these experiences. Scientists and religious scholars have used James's classic (and, at the time, groundbreaking) text to further classify the most common kinds of religious and spiritual experiences. *Mystical experiences,* for instance*,* involve a sense of connectedness or unity with all things. Such experiences are often felt by the subject to be beyond language, time, and space (Hood et al. 2001; James 1902). *Numinous experiences* are encounters with a god or some other abstract spiritual entity. Such experiences are often filled with awe, reverence, and a sense of wonder (Hood, Hill, and Spilka 2009; Otto 1937). *Calling experiences* are profoundly meaningful, temporary mental states that include a revelation or directive (Yaden and Newberg 2015). People who have had a calling experience may see a vision or hear a voice that directs them toward a particular life-path. For example, the New Testament recounts Saint Paul's experience on the road to Damascus, where he reported having a vision of God, who directed him to change his life (Longenecker 1997).

Overall, religion tends to place more emphasis on collective institutions, creeds, and practices, whereas spirituality depends more on individual belief and experience (Pargament 1999). From the perspective of neuroscience, some of these factors matter more than others. The more subjectively intense aspects of religious and spiritual experiences can be measured more readily because they are easier to detect.

MEASURING BELIEFS, ATTITUDES, AFFILIATIONS, AND MENTAL STATES

Before we can measure religious and spiritual beliefs and experiences, specific concepts must be defined and turned into *constructs*. Constructs are basically concepts made testable, and they constitute a basic part of scientific research (Kelly 2002). In order to create a construct, a given concept must be *operationalized,* or defined in a way that is useful for measurement (Sethi and King 1991). For example, religion (a concept) can be operationalized as religiosity (a construct) and then measured using a religiosity questionnaire (a measure). The *nomological net* is the name for the system of relationships between the many different constructs and their measures throughout various scientific fields (Cronbach and Meehl 1955).

Constructs can be measured by qualitative or quantitative means. One example of qualitative research would be self-report, which involves asking subjects to describe themselves or aspects of their experience, sometimes including the researcher's impressions

of the subject. Case studies, which analyze particular episodes in detail, are a common method of qualitative research. Some forms of content analysis—the interpretation of text by researchers—have been developed to make the analysis of such data more systematic (Strauss and Corbin 1990).

Quantitative research, on the other hand, reduces observable phenomena to numerical data (Todd 2004). Quantitative research can often remove human bias from the research process more effectively than do qualitative approaches. For example, a quantitative form of content analysis would be to use a computer program to count how many times certain words appear in writing (e.g., Schwartz et al. 2013). Methods like these can allow researchers to compare written descriptions of intense versus less intense spiritual experiences (e.g., Yaden, Eichstaedt, Schwartz, et. al. 2015).

Scales are a common tool for quantitative self-report research that provide a standard way of asking questions and analyzing the results. Scales are essentially surveys that ask participants to rate how much they agree with a series of statements. The book *Measures of Religiosity* (Hill and Hood 1999) lists a number of different scales for measuring different parts of religion and spirituality. For instance, the *Mysticism Scale* (M-Scale; Hood 1975), which measures mystical experiences, would ask how strongly you agree with the statement "I have felt at one with all things" on a scale from 1 (definitely disagree) to 5 (definitely agree). Another measurement is the *Index of Core Spiritual Experiences* (INSPIRIT; Kass et al. 1991), which measures a number of different experiences with God or a sense of divine presence. Additionally, the *Religiousness Measure* (Sethi and Seligman 1993) measures aspects of religious affiliation related to optimism about the future, including the degree to which one believes in an afterlife. Each of these scales has been validated or tested to ensure that the scale measures a construct accurately. Validity includes reliability testing, which ensures that the results are consistent across individuals taking the same test at different times (Patten 2000).

NEUROSCIENCE: A BRIEF ORIENTATION

THE NERVOUS SYSTEM

Before getting into the specifics of how neurochemistry is related to RSMEs, some familiarity with the nature and study of the brain is necessary. The nervous system is the part of the body that allows organisms to interact with their environments. Almost every multicellular organism (except the sponge) and even some single-celled organisms (like amoebas) have nervous systems. In most mammals, including humans, the nervous system is divided into two parts: the *central nervous system* (*CNS*) and the *peripheral nervous system* (*PNS*) (Peters, Palay, and Webster 1991).

The central nervous system includes the spinal cord and the brain. The brain is the center of the nervous system in almost all animals (starfish and jellyfish are rare exceptions). The brain provides information processing and allows for coordinated control over the body (Nieuwenhuys, Voogd, and van Huijzen 2007).

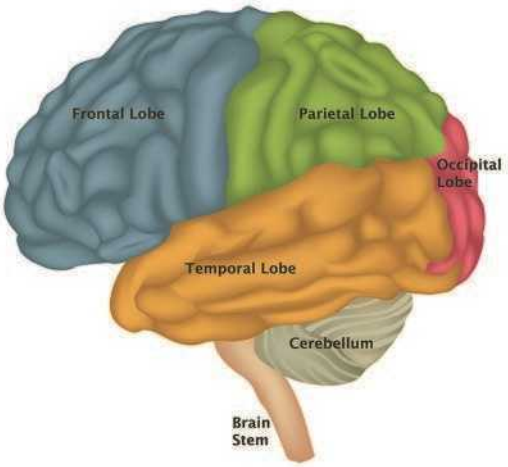
The peripheral nervous system includes the *autonomic nervous system*, which controls a number of bodily functions that are usually not under conscious control such as heart rate, breathing, and digestion. (Even so, some religious and spiritual practices have been shown to effectively provide practitioners with a limited amount of control over these autonomic functions.) The autonomic nervous system breaks down further into the *sympathetic* and

parasympathetic branches. The sympathetic branch is most widely known for its role in the "flight or fight response" or "stress response" that is triggered when under duress (Sapolsky 2004). The parasympathetic branch provides an oppositional function and is associated with the "rest and digest response" or "relaxation response," which religious and spiritual practices such as meditation and prayer can effectively induce (Benson 1975).

THE BRAIN

The brain has been imagined in a number of different ways throughout history. Some ancient Greeks thought the brain was just an organ to cool the blood and had nothing whatsoever to do with thought. Descartes thought "animal spirits" allowed the brain and body to function ([1650] 1989). The Industrial Revolution brought with it many mechanical metaphors for brain function; today, the metaphor of the brain as a computer is the most widely used. These conceptualizations can be helpful in representing how the brain functions, and they will likely continue to be applied as technology advances, but they can also limit our understanding if the metaphor is taken too far or too literally.

The human brain is divided into the left and right hemispheres, which can be visualized similarly to the eastern and western hemispheres of the Earth. These hemispheres share a great deal of functional overlap, though there are important differences. (It should be noted that the distinction between the "left-brained" rational type and "right-brained" creative type is a myth.) Connective tissue called the *corpus callosum* bridges the two hemispheres. Nobel Prize–winning research has shown that if the corpus callosum is cut (which used to be done in some cases of severe epilepsy), then two distinct intelligences can emerge in a single brain—and even compete for control over the body (Gazzaniga 1967). There was once a case in which a patient who had his corpus callosum cut was asked whether he believed in God. Amazingly, one hand (controlled by one hemisphere) responded by writing "no" while the other hand (controlled by the other hemisphere) wrote "yes" (Ramachandran 2004)!



Lateral view of the anatomy of the human brain. *The cortex of the human brain includes four different lobes: the frontal lobes are largely responsible for willful, intentional action and the coordination of information; the parietal lobes are responsible for social interactions, as well as spatial attention and orientation in space; the temporal lobes contain language processing centers and the emotional centers; and the occipital lobes contain visual processing centers. The cerebellum, one of the brain's subcortical structures, controls fine motor tasks.* © **ISTOCKPHOTO.COM/TERRIANA.**

The brain is further divided into four different lobes that are part of both hemispheres: the *frontal lobes,* the *parietal lobes,* the *temporal lobes,* and the *occipital lobes* (Luria 1976). These brain regions cover large amounts of space and therefore include a number of different functions within their boundaries. The frontal lobes are largely responsible for willful, intentional action and the coordination of information. The parietal lobes are responsible for social interactions, as well as spatial attention and orientation in space. The temporal lobes contain language processing centers and, deeper in, the emotional centers, or limbic system, including the hippocampus and the amygdala. The occipital lobes contain visual processing centers. It is important to remember that our understanding of the relationship

between brain structure and function is still quite general—one might just as easily ascribe one single climate to an entire continent (Bear, Connors, and Paradiso 2007).

The brain can then be divided between the *cortex* and *subcortical structures*. If the cortex is the Earth's crust, then the subcortical structures are the mantle. The cortex is a thin (~3 millimeter) outer layer made of gray matter (which is where the expression, "the pitter patter of gray matter" comes from). Most complex cognitive tasks, such as thought, language, and memory, are processed in the cortex. The cortex is divided into the lobes discussed in the previous paragraph. Subcortical structures include a number of structures that serve more specialized functions than the cortex, and include the *basal ganglia* (involved in motor control), the *thalamus* (relays sensory information to the cortex), the *hypothalamus* (involved in regulating general alertness and activation levels), and the *cerebellum* (controls fine motor tasks) (Bear, Connors, and Paradiso 2007).

NEURONS AND NEUROCHEMISTRY

Neurons are the cells that populate brain tissue and facilitate information exchange. The human brain has about 86 billion neurons (Azevedo et al. 2009)—somewhere between the number of humans on Earth (~7 billion) and the number of stars in the Milky Way (~200 billion). Neurons consist of a *soma* (the cell body), *dendrites*, which receive information from other neurons, and an *axon*, which transmits information to other neurons. Additionally, the axon can be coated by a *myelin sheath*, which increases the speed at which information can be transmitted. Neurons send information through an electrochemical process made possible by the capacity for neurons to (1) become activated and (2) transmit activation to other neurons. Neurons become activated and send their own "message" to other neurons when a certain threshold of activation is reached, which results from biochemical "messages" from other neurons. The interaction between neurons is where neurochemistry comes into play (Bear, Connors, and Paradiso 2007).

Neurons pass messages between one another through a neurochemical process. A neuron usually has an electrical charge, called its resting membrane potential (Davidson, Scherer, and Goldsmith 2003). When a neuron receives biochemical messages from other neurons, however, the neuron slightly decreases its negative charge. When a certain threshold is reached, it is called an *action potential*. The action potential produces an impulse that travels down the length of the axon and sends this activation, or "message," to other neurons by releasing chemicals into the space between neurons, called the synapse. Neurotransmitters are the chemicals that activated (presynaptic) neurons release into the synapse, which are then collected by the dendrites of other (postsynaptic) neurons (Breedlove, Rosenzweig, and Watson 2007). This whole process takes less than one hundredth of a second (Davidson, Scherer, and Goldsmith 2003).

Neurochemistry is the scientific study of neurotransmitters and their chemical reactions in the brain, including their effects on other biological systems in the brain and body (Brady et al. 2005). As mentioned, neurochemistry plays a fundamental role in facilitating information exchange in the brain by allowing neurons to communicate with one another. Without these neurochemical reactions in the brain, humans would be incapable of having any experiences, religious, spiritual, or otherwise (Newberg and d'Aquili 2000).

NEUROTRANSMITTERS

Neurotransmitters come in a number of different forms (amino acids, peptides, and monoamines) and are associated with a number of different functions. For the purposes of this chapter, the focus will be on those that seem most relevant to religion and spirituality.

Glutamate is the most widespread transmitter in the brain, estimated to be used at about half of all synapses. It is the primary excitatory neurotransmitter, meaning that it increases synaptic activity. The most common precursor is glutamine, which glial cells supply for neurons before being converted to glutamate by an enzyme called glutaminase (Hediger and Welbourne 1999). Some theories of RSMEs triggered by meditation posit that activation of the prefrontal cortex from focused attention results in glutamate release (Newberg and Iversen 2003).

Another important neurotransmitter is *gamma amino butyric acid* (*GABA*): the second most prevalent neurotransmitter. GABA is the primary inhibitory neurotransmitter and is responsible for *reducing* synaptic activity. This is just as important for the brain as is increased activity because effective signaling requires both turning pathways on and turning them off at the right times (Chebib and Johnston 1999). During meditation, for example, the glutamate released from prefrontal cortex activation may trigger GABA release in the thalamus, which may inhibit other cortical regions, resulting in increased feelings of connectedness with one's surroundings (Newberg and Iversen 2003).

Acetylcholine is a neurotransmitter associated with movement because of its role in the peripheral nervous system. Acetylcholine activates skeletal muscles by initiating the chain reaction for muscle contraction (though it reduces the contraction of cardiac muscles) (Warburton 1981). The release of glutamate and serotonin during meditation may increase the release of acetylcholine from the nucleus basalis, resulting in alterations to attention (Mohandas 2008).

The neurotransmitter *serotonin* is involved in the regulation of mood, sleep, and appetite. It plays a role in memory and learning and has been suggested to play a large role in other subjective states. Researchers have observed low levels of serotonin to be associated with a range of mental disorders, such as depression and obsessive-compulsive disorder (Berger, Gray, and Roth 2009). Research on the serotonin system has resulted in contradictory findings, with some studies showing a strong relationship between serotonin levels and spiritual beliefs (Borg et al. 2003) and others showing no relationship (Karlsson et al. 2012).

Dopamine is best known for its role in motivation and reward; increased motivation to pursue appealing stimuli is linked with increased dopamine levels. It is often speculated that dopamine is involved in the perception of pleasure (Salamone 1996). Dopamine is released during meditation and many other religious practices (Kjaer et al. 2002; Newberg and Iversen 2003).

Epinephrine and *norepinephrine* are both implicated in the "fight or flight" response. More popularly known as adrenaline and noradrenaline, respectively, they also increase heart rate, blood flow to skeletal muscles, and release of glucose reserves during periods of extreme stress (Brady et al. 2005). Prayer, meditation, and other calming religious practices are generally associated with decreased epinephrine in urine and plasma samples (Newberg and Iversen 2003).

Oxytocin is a neuropeptide with effects in the limbic system. Oxytocin has been implicated across a wide range of social behaviors, including pair bonding and maternal aggression (Neumann 2008). Plasma oxytocin levels increase during sexual arousal and are especially high during orgasm (Carmichael et al. 1987). Oxytocin is associated with relaxation (Carter 2007) and is believed to promote prosocial behavior (Kirsch et al. 2005).

Religious and spiritual experiences are likely associated with oxytocin release, which may contribute to feelings of emotional warmth and closeness (Grigorenko et al. 2011).

The neurotransmitter *vasopressin* is also a neuropeptide. It often is studied in tandem with oxytocin, owing to its similarly socially connective effects. Vasopressin is associated with pair bonding in nonhuman mammals (Pitkow et al. 2001; Lim and Young 2004). It has also been suggested to aid in learning and in the formation of new memories (Weingartner et al. 1981). This neuropeptide may contribute to the sense of social connection felt during some religious and spiritual experiences and may make such experiences more memorable.

Finally, the neurotransmitter *cortisol* is a hormone released by the adrenal gland in response to stress. This hormone is commonly measured to gauge stress and anxiety in laboratory settings. Decreased serum levels have been observed during meditation sessions (Newberg and Iversen 2003).

NEUROIMAGING

Brain activity can be studied in various ways, each with its own advantages and disadvantages. Because neurons firing inside a living person cannot be observed firsthand, scientists have developed techniques for identifying neuronal activity through proxies. Although all techniques come with limitations as to accuracy and ability for results to be interpreted, modern brain imaging offers powerful insights into the workings of the brain (Dougherty, Rauch, and Rosenbaum 2008).

What are some of the most helpful techniques when it comes to trying to understand religion and the brain? *Magnetic resonance imagining* (*MRI*) is a brain-imaging technique that can measure brain structure and activity (the latter is referred to as functional MRI or fMRI). A powerful magnet aligns the hydrogen nuclei of water atoms inside of the brain and can determine changes in the amount of brain tissue or in the amount of blood flow (Jezzard, Matthews, and Smith 2001). Typically, the more active a particular brain structure, the more blood flow it receives. In addition, MRI has been used to quantify the volume of particular brain structures. MRI has been used to measure short and long-term changes in the frontal lobes of meditators (Lazar et al. 2000). Magnetic resonance spectroscopy (MRS) has also been used to evaluate the concentration of different neurotransmitters, such as GABA, associated with meditation practices (Streeter et al. 2007).

Single-photon emission computed topography (*SPECT*) uses gamma rays to render a 3-D map of the patient's brain. The patient is administered a radioactive compound and observed by a "gamma camera," which is sensitive to gamma radiation. SPECT imaging can be used with a wide array of radioactive compounds that follow some aspect of the brain's function such as blood flow or neurotransmitter activity (Ichise, Meyer, and Yonekura 2001). This technique has been used to study feelings of unity during prayer and meditation (Newberg et al. 2001).

Positron emission topography (*PET*) is similar to SPECT, except that its radioactive compounds exploit the collision of positrons with electrons to produce two separate gamma photons, which travel in opposite directions. Like SPECT imaging, PET imaging allows for the evaluation of many different physiological processes including blood flow and neurotransmitters. PET also includes the tracer fluorodeoxyglucose (FDG), which allows for the measurement of cerebral glucose metabolism (Ichise, Meyer, and Yonekura 2001). PET has also been used to study changes in dopamine release during meditation (Kjaer et al. 2002).

Electroencephalography (*EEG*) is different from the above techniques in that it measures electrical activity directly, rather than through a proxy such as blood flow. By placing electrical sensors on the scalp, researchers administering an EEG test can measure the amount of electrical activity emitted by the brain right below the skull (Evans and Abarbanel 1999). The portability of EEG equipment assisted scientists in conducting the first brain studies of monks in India (Lutz, Dunne, and Davidson 2007).

Although these imaging techniques can measure brain activity related to neurotransmitter activity, there are also methods to directly measure serum levels of neurotransmitters. These include blood and urine tests that isolate specific chemical indicators of neurotransmitter levels (Newberg and Iversen 2003). Neuroimaging and other neurotransmitter testing technologies allow researchers to measure neurochemical changes, but each contains its own trade-offs in terms of measurements, accuracy, cost, ease of use, and applicability to questions about religion or spirituality.

THE NEUROSCIENCE OF RELIGIOUS AND SPIRITUAL EXPERIENCE

When the complexities of neuroscience are combined with the difficulties of defining religion and spirituality, the result, not surprisingly, is that the neuroscience of religion and spirituality is far from simple. There are no easy answers here—no "God spot" or "God chemical" in the brain that explains religion and spirituality in full (Newberg and d'Aquili 2000). However, the study of neuroscience can inform our understanding of how religion and spirituality influence well-being, mental illness, health, and group behavior.

There are a number of models of how the brain mediates, or facilitates, various aspects of religion and spirituality. For example, different neurological models underlie the propensity for belief versus disbelief, the effects of coming together in a religious ritual, and the changes to subjective experience that occur during religious and spiritual experiences (Newberg and d'Aquili 2000). The following sections describe several particularly promising models of how the brain changes in response to specific aspects of religion or spirituality.

RELIGIOUS AND SPIRITUAL EXPERIENCES FROM MEDITATION

Meditation of various kinds has been used since antiquity to produce different forms of religious and spiritual experience. Although this is not the primary goal of many forms of meditation practice, it is the goal of some (Vago and Silbersweig 2012). Among the most widespread meditation practices is *mindfulness*, a practice with origins in Buddhist thought. As a technique, it emphasizes judgment-free awareness and simply being present. Practitioners of meditation strive to observe their own thought patterns and experiences without any specific attitude or reaction, simply being conscious of them (Brown, Ryan, and Creswell 2007). It has been suggested that mindfulness meditation, when practiced over extended periods, is associated with increased self-awareness, increased positive affect, and reduced stress (Brown and Ryan 2003).

Transcendental Meditation, or TM, was solidified as a popular modern movement under Maharishi Mahesh Yogi during the 1960s. It emphasizes repeated use of a mantra while observing one's own thought patterns (Mahesh Yogi 1963). People engaged in transcendental meditation describe heightened levels of alertness during transcendental meditation sessions (Cahn and Polich 2006).

Loving-kindness meditation or *compassion meditation* often starts with the practitioners focusing on their sense of self-love and expanding outward gradually to loved ones, friends, people toward whom they feel neutral, and people toward whom they feel averse (Hoffman, Grossman, and Hinton 2011). The eventual goal is to focus on all of them at once and ultimately expand to the entire world (Ñāṇamoli 1991). Loving-kindness meditation can make people more sensitive to the emotions of others by affecting the neural pathways associated with empathy (Lutz et al. 2008).

Meditation has been found to be a reliable trigger of spiritual experiences (Newberg et al. 2001). Many forms of meditation involve the intentional direction of attention toward a particular thought, image, or object over a long period of time. Neuroimaging studies have shown that paying attention for long periods of time is associated with activation in the right *prefrontal cortex* (Ingvar 1994; Posner and Petersen 1990). This pattern of activation has also been observed during meditation (Hölzel et al. 2011; Vago and Silbersweig 2012). For example, a SPECT study of Tibetan Buddhist meditation practitioners showed increased prefrontal cortex activity (Newberg et al. 2001).

Prefrontal cortex activity from meditation may activate the thalamus, a common pathway of activation (Cornwall and Phillipson 1988). Glutamate is the most likely neurotransmitter to mediate activity between the prefrontal cortex and the thalamus (Cheramy, Romo, and Glowinski 1987). The thalamus is a subcortical structure responsible for relaying sensory information to the cortex. One cortical area to which the thalamus sends sensory information is the superior parietal lobe, which is associated with locating one's body in space, as well as representing the boundary between one's own body and the surrounding environment (Bucci, Conley, and Gallagher 1999; Newberg and d'Aquili 2000). When one region of the thalamus, the reticular nucleus, is activated, it may send GABA to another region of the thalamus, the geniculate nucleus. The inhibitory effect of GABA may effectively block sensory pathways to the *superior parietal lobe* (Newberg and Iversen 2003).

Meditation influences a number of other neurochemical systems. A study on Yoga Nidra meditation showed an increase in dopaminergic activity (Kjaer et al. 2002). Serotonin activity has also been shown to increase during meditation (Walton et al. 1995). Other studies have also found increased glutamate and GABA levels (Elias, Guich, and Wilson 2000), which could result in the release of endogenous opioids (Newberg and Iversen 2003). These findings demonstrate the complexity of practices such as meditation and their resistance to simplistic reduction.

In summary, sustained attention may activate the prefrontal cortex, resulting in the activation of one region of the thalamus through glutamate intervention, which goes on to inhibit another region of the thalamus with GABA, thus blocking neural information flow to the superior parietal lobe. The resulting *deafferentation*, or cessation of neural signaling, to the parietal lobe may result in a feeling of unity with one's environment. This pattern of activation may underlie experiences that lead people to describe feeling at one with their surroundings (Newberg and d'Aquili 2000; see also Figure 17.1).

RELIGIOUS AND SPIRITUAL EXPERIENCES FROM PRAYER

Prayer may follow a similar pathway of activation to that outlined above, as praying Franciscan nuns were included in the foundational study for this model (Newberg et al. 2001). There are, however, some differences between meditation and prayer that are worth noting.

Brain Process Associated with Meditation

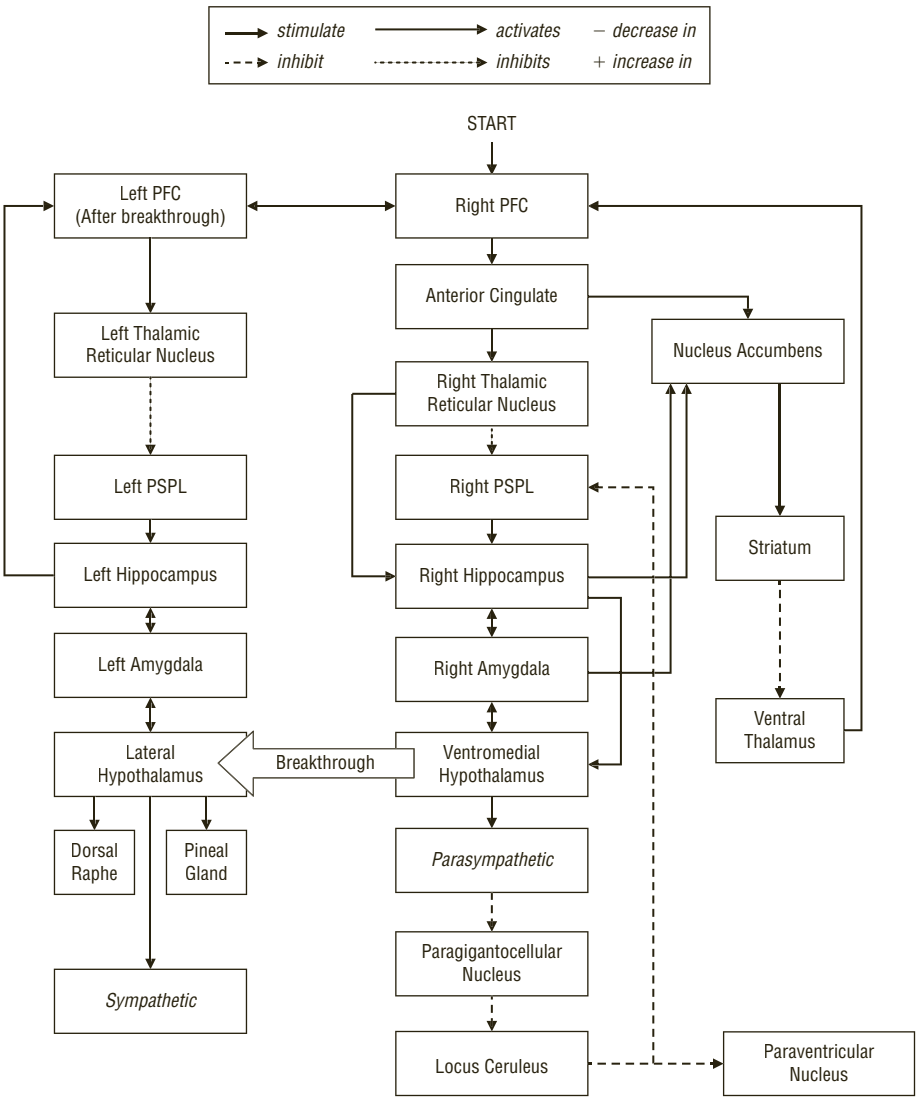


Figure 17.1. *Many forms of meditation involve the intentional direction of attention toward a particular thought, image, or object over a long period of time. Such sustained attention may activate the prefrontal cortex (PFC), resulting in the activation of one region of the thalamus through glutamate intervention, which goes on to inhibit another region of the thalamus with GABA (a neurotransmitter), thus blocking neural information flow to the posterior superior parietal lobe (PSPL). The resulting cessation of neural signaling to the parietal lobe may result in a feeling of unity with one's environment.* **ANDREW B. NEWBERG. ADAPTED FROM NEWBERG, 2016.**

Primarily, prayer studies show increased activity in brain regions associated with theory of mind, the understanding of other people's mental states, and social cognition, which entails the ability to mentally process social interactions (Castelli et al. 2000). These regions include medial frontal and inferior parietal regions, among many others (Gabbard 2005; Mohandas 2008).

This activation of social regions makes sense, given that prayer involves the (at least) perceived interaction with another mental entity, such as a deity or other divine beings. Even thinking about divine emotions (such as love or anger) leads to increased activity in these areas (Kapogiannis et al. 2009). Thinking about the divine often involves an intuitive sense of agency, or believing that one is communicating with another mental entity (Barrett, Richert, and Driesenga 2001). Therefore, prayer may activate more brain regions associated with social communication than practices like meditation, unless the meditation practice is focused on others as during compassion meditation.

RELIGIOUS AND SPIRITUAL EXPERIENCES FROM GROUP RITUALS

Group rituals involving singing or dancing are often excitatory in nature, much of which might have to do with interpersonal cooperation. Observing other people's behavior activates our own brain areas responsible for those actions (Knoblich and Sebanz 2006; Rizzolatti et al. 1996), and synchronized action can strengthen social bonds and feelings of affiliation between participants (Hove and Risen 2009). This might explain why song and dance feature so prominently in religious rituals and why places of worship often make use of collective participation, such as call-and-response and collective chants. Both musical activity and active movement may influence the production of endorphins (Tarr, Launay, and Dunbar 2014), which likely contributes to the social and subjective aspects of group rituals, too.

The process outlined in the meditation section is typically associated with parasympathetic activation—meditation is usually relaxing (Benson 1975; McGonigal 2012). There is evidence that this process could be triggered by the sympathetic nervous system as well. That is, intensely quiescent or intensely exciting experiences could trigger a deafferentation of the superior parietal lobe, resulting in feelings of connectedness with one's surroundings (Gellhorn and Kiely 1972). This could occur through a "paradoxical activation" from the rhythmic aspects of group practices. If the synchrony is perceived as highly meaningful or interesting, extreme activation of the parasympathetic branch of the autonomic nervous system could trigger activation of the sympathetic branch, or vice versa. Thus, the reticular activating system and amygdala could become activated (Newberg 2002). This could result in a profound sense of connection with other participants in the religious or spiritual ritual.

RELIGIOUS AND SPIRITUAL EXPERIENCES FROM PSYCHEDELIC DRUGS

Psychedelic substances are another common trigger of religious and spiritual experiences. Archaeological evidence suggests that psychoactive compounds have been used since ancient times for religious and spiritual purposes (Ellens 2014). Psychedelic substances offer an opportunity to more directly test the influence of neurochemistry on religious and spiritual states.

The first major scientific study on the effects of psychedelic substances on religious and spiritual states has been nicknamed "the Good Friday Experiment." In this study, divinity students were administered either *psilocybin*, the active ingredient in "mushrooms," or

niacin, an inert substance, at a Christian Good Friday mass (Pahnke 1966). Those who received the psilocybin reported profound religious and spiritual experiences at much higher rates than those given niacin, even though both groups attended the same service. The positive benefits of these experiences lasted many months, and some of the subjects reported that their experiences were still meaningful decades later (Doblin 1991). The famous religious historian and theologian Huston Smith was a subject in this study (Smith et al. 2004).

Some researchers, swept up with enthusiasm for what they viewed as the revolutionary potential of psychedelic substances, promoted widespread use of these substances by the public (Baumeister and Placidi 1983). Predictably, some individuals were unprepared and had negative experiences. Some high-profile legal cases resulted in widespread legal suppression of the use and research of psychedelic substances (Ellens and Roberts 2015). These missteps have provided important lessons to researchers and have resulted in a widespread emphasis on ethical considerations (Griffiths et al. 2006; Grob et al. 2011; Yaden, Anderson, Mattar, and Newberg 2015).

More recent research on psychedelic substances is being conducted under the strictest ethical guidelines and experimental design. For example, Griffiths and colleagues (2006) conducted groundbreaking research at Johns Hopkins using psilocybin. This study sought to replicate the Good Friday Experiment using a more rigorous design. The control substance, methylphenidate (Ritalin), was more subjectively visceral, whereas niacin has essentially no subjective effects. Furthermore, researchers and subjects were blinded to condition—neither group knew which substance the subjects would receive—a research practice called a *double blind*. Both of these considerations, among others, greatly enhanced the study's design.

The findings were dramatic. Subjects who received psilocybin reported that their experiences were among the most meaningful and spiritually significant of their entire lives. Most of the subjects who received psilocybin classified their experiences as mystical, according to a scale developed to measure religious and spiritual experiences marked by feelings of unity. Positive benefits from the experience included increased positive mood and more altruistic behavior; many of these benefits persisted for over a year (Griffiths et al. 2008). Another study on terminal patients with psilocybin found similar results (Grob et al. 2011).

NEUROCHEMICAL MECHANISMS IN RELIGIOUS AND SPIRITUAL PHENOMENA

THE NEUROCHEMISTRY OF PSYCHEDELIC SUBSTANCES

The process of evaluating the neurochemical mechanisms in religious and spiritual phenomena can benefit from a number of related approaches. One approach draws on knowledge of psychedelics and their effects on the brain, which involve neurotransmitters heavily involved in religious and spiritual experience.

The most common psychedelic substances include psilocybin (magic mushrooms), *lysergic acid diethylamide* (*LSD*), *N,N-dimethyltryptamine* (*DMT*), the active ingredient in the drug *ayahuasca*), and *mescaline* (peyote). Toxicity of these substances is generally low, though there are several potential toxic effects which have been reported, and thus, their use must be carefully considered (Jaffe 1990; Tittarelli et al. 2015). Addiction is relatively

uncommon, though the data on each drug is not clear (O'Brien 1996). Instances of psychedelic-induced psychosis are generally rare (< 0.01%) (McGlothlin and Arnold 1971; Nichols 2004).

Psilocybin (the active ingredient in "magic mushroom") is a well-known substance that has been used by shamans throughout history. Psilocybin occurs naturally as a compound of certain species of mushrooms, though it can also be synthesized (Guzmán, Allen, and Gartz 1998). The body converts psilocybin to psilocin, which can cause euphoria, visual and auditory hallucinations, synesthesia, and distortion of the user's perception of time (Diaz 1997; Peden et al. 1981). Ancient Saharan rock paintings suggest that humans have consumed psilocybin mushrooms for thousands of years, presumably for religious ceremonies (Samorini 1992).

Lysergic acid diethylamide (*LSD*), first synthesized by the chemist Albert Hoffman in 1938 (Hoffman 1996), was made popular by countercultural figures in the 1960s. Doses are usually between 20 and 100 micrograms (Greiner, Burch, and Edelberg 1958). The range of effects varies greatly from person to person, often including intense changes in visual and auditory perception. Most users experience euphoria and giddiness, whereas others experience tension and anxiety (Katz, Waskow, and Olsson 1968).

N,N-Dimethyltryptamine (DMT), as noted earlier, is one of the primary active ingredients in ayahuasca, a drink consumed by South American shamans for spiritual purposes (Rivier and Lindgren 1972). DMT is considered a particularly spiritual drug in popular culture. Its effects include visual hallucinations, dissociation, ecstasy, anxiety, and feelings of being overwhelmed. DMT sessions are considerably fast and intense compared to those of other drugs (Strassman, Qualls, & Uhlenhuth 1994).

3,4,5-Trimethoxyphenethylamine (mescaline) occurs naturally as a compound in the peyote cactus. Archaeological evidence suggests that indigenous North Americans have smoked peyote for nearly six thousand years (El-Seedi et al. 2005). Psychedelic effects are similar to those of LSD and psilocybin, with bright visual hallucinations, impaired perception of time, and intense emotion (Laing 2003).

Many of these psychedelic substances work primarily through the serotonin system. Serotonin neurotransmitters come in a number of different receptor types, 5-HT1 through 5-HT7, which further break down into subtypes indicated by letters. The psychedelic substances mentioned above act on 5-HT2a serotonin receptors (Aghajanian and Marek 1999; Nelson et al. 1999; Scruggs et al. 2000; Ebersole et al. 2003). In particular, serotonin acts on receptors in cortical regions, including frontal, temporal, parietal, and occipital regions (Nichols 2004). The thalamus, which receives and directs sensory input, and the locus coeruleus, known for its role in detecting novelty, have also been strongly implicated in psychedelic research (Marek and Aghajanian 1999; Nichols 2004).

Psychedelic substances have certain neurochemical similarities to meditation. Like meditation, they have been shown to increase glutamate transmission in the cortex (Nichols 2004). Although glutamate secretion in the frontal cortex is associated in particular with the detection of novel sensory input or focused attention, psychedelic substances activate glutamate secretion regardless of sensory stimuli (Martín-Ruiz et al. 2001). Additionally, psychedelic substances also influence GABA activity in the thalamus, which may result in inhibition of cortical regions (Edelman 2003; Nichols 2004), similar to the inhibition observed during meditation (Newberg and Iversen 2003).

RELIGIOUS AND SPIRITUAL EXPERIENCES AND CORTICAL REGIONS

In summary, meditation, group rituals, and psychedelic substances have each been shown to influence some similar pathways. Each of these triggers tends to affect glutamate release in frontal regions and stimulate thalamic GABA secretion, which may inhibit other cortical regions.

Newberg and colleagues suggested that spiritual practices inhibit the superior parietal lobe (Newberg et al. 2001). More recent research also points to a region slightly posterior to the temporal lobe but anterior to the superior parietal lobe: the inferior region of the parietal lobe. For example, researchers (Urgesi et al. 2010) administered a scale to patients who were having cancerous tumors removed from anterior and posterior regions. Results indicated that patients who had tumors removed from inferior parietal regions showed an increased propensity for religious and spiritual beliefs and experiences. Other research has implicated both the inferior and superior regions of the parietal lobe (Beauregard and O'Leary 2007). These parietal regions are usually associated with representing bodily boundaries and one's position in space. Inhibitions of these regions could result in enhanced feelings of unity or connectedness with one's surroundings.

The temporal lobes have also long been associated with religious and spiritual experiences. The observation that epileptic episodes can stimulate religious and spiritual experiences goes back to ancient Greece, where it was called divine or the "sacred disease" (Turnbull et al. 2005). Other researchers have developed theoretical frameworks around religious and spiritual experiences based on these epilepsy observations (Persinger 1987; Saver and Rabin 1997). About 1 to 5 percent of temporal lobe epilepsy patients continue to report religious and spiritual experiences during their seizures.

Emerging research using noninvasive brain stimulation technology may help to pinpoint more specific regions of the cortex involved in various aspects of religious and spiritual experiences. *Noninvasive brain stimulation*, the practice of using either magnetic pulses or electrical stimulation to influence neural activity, has been shown to enhance a number of abstract cognitive functions such as learning, memory, and moral reasoning (Hamilton, Messing, and Chatterjee 2011). Preliminary research has shown that this form of stimulation can influence religious and spiritual identification (Crescenti et al. 2014). Noninvasive brain stimulation technology is now being used to induce aspects of spiritual experiences having to do with feelings of self-transcendence and to test enhancements to meditation practice (Yaden and Newberg 2014).

Although cortical activity certainly plays a part in explaining how certain triggers result in spiritual experiences, it is important to note the many neurochemical differences between these triggers and the subjective experiences that can result.

RELIGIOUS BELIEFS AND NEUROCHEMISTRY

Neurochemistry not only mediates the effects of practices and experiences, but also influences religious and spiritual beliefs.

The serotonin system has been implicated in spiritual beliefs. Some researchers have found that the density of serotonin receptors in certain brain regions is predictive of whether or not someone will have spiritual beliefs (Borg et al. 2003). Other researchers have also found that serotonin levels influence endorsement of religious and spiritual beliefs (Kirk, Eaves, and Martin 1999; Lorenzi et al. 2005). However, a larger and more recent study found no relationship between 5-HT receptor density and spirituality (Karlsson 2012).

These contradictory findings indicate that further research is necessary to untangle the relationship between the serotonin system and spiritual beliefs. Despite what is sometimes presented in exaggerated news stories, it usually takes a number of studies for scientific consensus to emerge.

The dopaminergic system is also related to spiritual beliefs. A particular type of Parkinson's disease, which primarily damages dopaminergic neurons (Dauer and Przedborski 2003), lessens religious beliefs and behavior (McNamara et al. 2001; Butler, McNamara, and Durso 2010). Other studies show that individuals with Parkinson's disease report less participation in religious and spiritual practices, fewer religious and spiritual experiences, and less positive emotion related to religious and spiritual ideals (Butler et al. 2011). Notably, the cohort of Parkinson's patients with lessened religious and spiritual beliefs and behavior are those with right forebrain damage, specifically (McNamara and Butler 2013).

It remains unclear whether the neurochemical differences between individuals reviewed in this chapter are causal or correlational. That is, do certain beliefs change neurotransmitter levels over time? Or do differences in neurochemistry determine the kinds of beliefs people adopt? More research is necessary to understand the nature of this relationship. For example, some scientists estimate that, like many psychological factors, the propensity for religious and spiritual beliefs is about 50 percent genetic (Kirk, Eaves, and Martin 1999). Some researchers have isolated more specific genes related to religious and spiritual beliefs (Hamer 2005). Despite these genetic predispositions, a number of other environmental, circumstantial, and psychological factors contribute to religious and spiritual beliefs (Newberg and d'Aquili 2000). Although neurochemistry plays a role in determining the kinds of beliefs an individual adopts, there are many other factors at play.

The most compelling work in the neurochemistry of religion and spirituality demonstrates that there are no simple answers here. Without a doubt, some people will continue to claim that religion and spirituality can be reduced to "just" X or Y brain function, while others will claim that religion and spirituality cannot be the subject of scientific research. There is also a third position. Although the neuroscience of religion and spirituality may never tell us whether God or spiritual realities do or do not exist, this research can tell us quite a lot about human nature and about how the benefits of religious and spiritual practices are mediated. Furthermore, interventions involving alterations to neurochemistry may play a role in the religious and spiritual lives of individuals by helping to create the conditions for religiously and spiritually significant experiences—perhaps with the potential to increase well-being and altruistic behavior.

Summary

This chapter has provided an overview of how religion and spirituality can be studied from the perspective of neuroscience. Today, technological advances in neuroimaging and intervention tools are rapidly developing, and interventions that involve religious and spiritual practices, such as meditation, are gaining in popularity. Neuroscience is sure to play an instrumental role as the study of religion and spirituality continues into the future. Three summarizing statements follow.

First, neuroscience research does allow scientists to learn more about religious and spiritual beliefs, practices, and experiences, as well as about human nature more broadly.

Specifically, neuroscience research allows scientists to learn about certain predispositions for religious and spiritual beliefs and practices, as well as how their psychological effects are mediated.

Second, although the research is still scattered and includes some contradictory evidence, there are certain fruitful convergences. There is consensus, for example, that religious and spiritual practices affect a complex network of brain structures, with some common components depending on the specific elements of the practice. Additionally, certain psychoactive substances that have known neurochemical effects can induce religious, spiritual, and mystical experiences, even in laboratory settings.

Finally, the neuroscientific study of religion and spirituality is not likely to offer any absolute metaphysical answers. At this point, neuroscience alone cannot tell us whether changes from religious and spiritual practices, rituals, or beliefs are the result of real perceptions or illusory projections. These questions are likely to remain substantially in the domains of philosophy and theology for the foreseeable future. Neurotheology recognizes that answering epistemological questions may ultimately require a multidisciplinary approach that integrates elements of neuroscience, religious and spiritual phenomena, and philosophy and theology, and will perhaps expand to include other fields related to the study of religion and spirituality in human life.

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