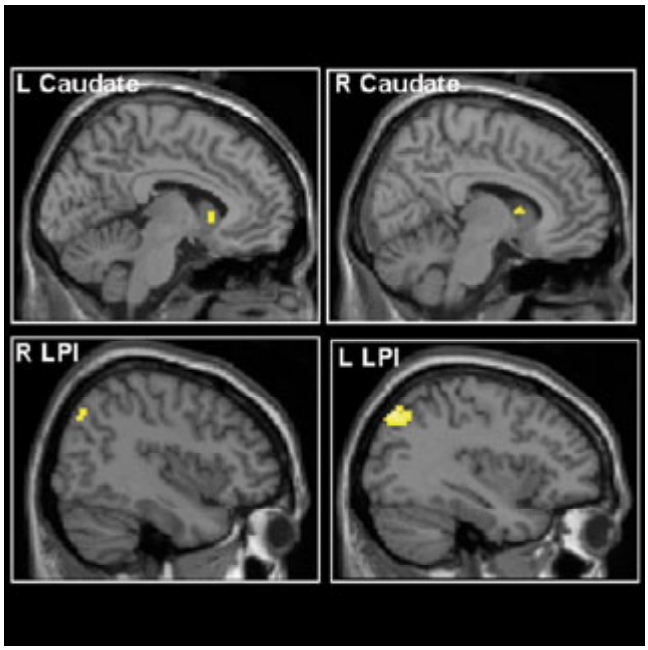
SEARCHING FOR GOD IN THE BRAIN

Researchers are unearthing the roots of religious feeling in the neural commotion that accompanies the spiritual epiphanies of nuns, Buddhists and other people of faith



MYSTICAL HOT SPOTS: In a 2006 study the recall by nuns of communion with God invigorated the brains caudate nucleus, insula, inferior parietal lobe (IPL) and medial orbitofrontal cortex (MOFC), among other brain regions.

The doughnut-shaped machine swallows the nun, who is outfitted in a plain T-shirt and loose hospital pants rather than her usual brown habit and long veil. She wears earplugs and rests her head on foam cushions to dampen the device's roar, as loud as a jet engine. Supercooled giant magnets generate intense fields around the nun's head in a high-tech attempt to read her mind as she communes with her deity.

The Carmelite nun and 14 of her Catholic sisters have left their cloistered lives temporarily for this claustrophobic blue tube that bears little resemblance to the wooden prayer stall or sparse room where such mystical experiences usually occur. Each of these nuns answered a call for volunteers "who have had an experience of intense union with God" and agreed to participate in an experiment devised by neuroscientist Mario Beauregard of the University of Montreal. Using functional magnetic resonance imaging (fMRI), Beauregard seeks to pinpoint the brain areas that are active while the nuns recall the most powerful religious epiphany of their lives, a time they experienced a profound connection with the divine. The question: Is there a God spot in the brain?

The spiritual quest may be as old as humankind itself, but now there is a new place to

look: inside our heads. Using fMRI and other tools of modern neuroscience, researchers are attempting to pin down what happens in the brain when people experience mystical awakenings during prayer and meditation or during spontaneous utterances inspired by religious fervor.

Such efforts to reveal the neural correlates of the divine — a new discipline with the warring titles "neurotheology" and "spiritual neuroscience"—not only might reconcile religion and science but also might help point to ways of eliciting pleasurable otherworldly feelings in people who do not have them or who cannot summon them at will. Because of the positive effect of such experiences on those who have them, some researchers speculate that the ability to induce them artificially could transform people's lives by making them happier, healthier and better able to concentrate. Ultimately, however, neuroscientists study this question because they want to better understand the neural basis of a phenomenon that plays a central role in the lives of so many. "These experiences have existed since the dawn of humanity. They have been reported across all cultures," Beauregard says. "It is as important to study the neural basis of [religious] experience as it is to investigate the neural basis of emotion, memory or language."

Mystical Misfirings

Scientists and scholars have long speculated that religious feeling can be tied to a specific place in the brain. In 1892 textbooks on mental illness noted a link between "religious emotionalism" and epilepsy. Nearly a century later, in 1975, neurologist Norman Geschwind of the Boston Veterans Administration Hospital first clinically described a form of epilepsy in which seizures originate as electrical misfirings within the temporal lobes, large sections of the brain that sit over the ears. Epileptics who have this form of the disorder often report intense religious experiences, leading Geschwind and others, such as neuropsychiatrist David Bear of Vanderbilt University, to speculate that localized electrical storms in the brain's temporal lobe might sometimes underlie an obsession with religious or moral issues.

Exploring this hypothesis, neuroscientist Vilayanur S. Ramachandran of the University of California, San Diego, asked several of his patients who have temporal lobe epilepsy to listen to a mixture of religious, sexual and neutral words while he tested the intensity of their emotional reactions using a measure of arousal called the galvanic skin response, a fluctuation in the electrical resistance of the skin. In 1998 he reported in his book Phantoms in the Brain (William Morrow), co-authored with journalist Sandra Blakeslee, that the religious words, such as "God," elicited an unusually large emotional response in these patients, indicating that people with temporal lobe epilepsy may indeed have a greater propensity toward religious feeling.

The key, Ramachandran speculates, may be the limbic system, which comprises interior regions of the brain that govern emotion and emotional memory, such as the amygdala and hypothalamus. By strengthening the connection between the temporal lobe and these emotional centers, epileptic electrical activity may spark religious feeling.

To seal the case for the temporal lobe's involvement, Michael Persinger of Laurentian University in Ontario sought to artificially re-create religious feelings by electrically stimulating that large subdivision of the brain. So Persinger created the "God helmet," which generates weak electromagnetic fields and focuses them on particular regions of the brain's surface.

In a series of studies conducted over the past several decades, Persinger and his team have trained their device on the temporal lobes of hundreds of people. In doing so, the researchers induced in most of them the experience of a sensed presence — a feeling that someone (or a spirit) is in the room when no one, in fact, is — or of a profound state of cosmic bliss that reveals a universal truth. During the three-minute bursts of stimulation, the affected subjects translated this perception of the divine into their own cultural and religious language — terming it God, Buddha, a benevolent presence or the wonder of the universe.

Persinger thus argues that religious experience and belief in God are merely the results of electrical anomalies in the human brain. He opines that the religious bents of even the most exalted figures — for instance, Saint Paul, Moses, Muhammad and Buddha — stem from such neural quirks. The popular notion that such experiences are good, argues Persinger in his book Neuropsychological Bases of God Beliefs (Praeger Publishers, 1987), is an outgrowth of psychological conditioning in which religious rituals are paired with enjoyable experiences. Praying before a meal, for example, links prayer with the pleasures of eating. God, he claims, is nothing more mystical than that.

Expanded Horizons

Although a 2005 attempt by Swedish scientists to replicate Persinger's God helmet findings failed, researchers are not yet discounting the temporal lobe's role in some types of religious experience. After all, not all such experiences are the same. Some arise from following a specific religious tradition, such as the calm Catholics feel when saying the rosary. Others bring a person into a perception of contact with the divine. Yet a third category might be mystical states that reveal fundamental truths opaque to normal consciousness. Thus, it is possible that different religious feelings arise from distinct locations in the brain. Individual differences might also exist. In some people, the neural seat of religious feeling may lie in the temporal lobe, whereas in others it could reside

elsewhere.

Indeed, University of Pennsylvania neuroscientist Andrew Newberg and his late colleague, Eugene d'Aquili, have pointed to the involvement of other brain regions in some people under certain circumstances. Instead of artificially inducing religious experience, Newberg and d'Aquili used brain imaging to peek at the neural machinery at work during traditional religious practices. In this case, the scientists studied Buddhist meditation, a set of formalized rituals aimed at achieving defined spiritual states, such as oneness with the universe.

When the Buddhist subjects reached their self-reported meditation peak, a state in which they lose their sense of existence as separate individuals, the researchers injected them with a radioactive isotope that is carried by the blood to active brain areas. The investigators then photographed the isotope's distribution with a special camera—a technique called single-photon-emission computed tomography (SPECT).

The height of this meditative trance, as they described in a 2001 paper, was associated with both a large drop in activity in a portion of the parietal lobe, which encompasses the upper back of the brain, and an increase in activity in the right prefrontal cortex, which resides behind the forehead. Because the affected part of the parietal lobe normally aids with navigation and spatial orientation, the neuroscientists surmise that its abnormal silence during meditation underlies the perceived dissolution of physical boundaries and the feeling of being at one with the universe. The prefrontal cortex, on the other hand, is charged with attention and planning, among other cognitive duties, and its recruitment at the meditation peak may reflect the fact that such contemplation often requires that a person focus intensely on a thought or object.

Neuroscientist Richard J. Davidson of the University of Wisconsin－Madison and his colleagues documented something similar in 2002, when they used fMRI to scan the brains of several hundred meditating Buddhists from around the world. Functional MRI tracks the flow of oxygenated blood by virtue of its magnetic properties, which differ from those of oxygen-depleted blood. Because oxygenated blood preferentially flows to where it is in high demand, fMRI highlights the brain areas that are most active during—and thus presumably most engaged in—a particular task.

Davidson's team also found that the Buddhists' meditations coincided with activation in the left prefrontal cortex, again perhaps reflecting the ability of expert practitioners to focus despite distraction. The most experienced volunteers showed lower levels of activation than did those with less training, conceivably because practice makes the task easier.

This theory jibes with reports from veterans of Buddhist meditation who claim to have reached a state of “effortless concentration,” Davidson says.

What is more, Newberg and d’Aquili obtained concordant results in 2003, when they imaged the brains of Franciscan nuns as they prayed. In this case, the pattern was associated with a different spiritual phenomenon: a sense of closeness and mingling with God, as was similarly described by Beauregard’s nuns. “The more we study and compare the neurological underpinnings of different religious practices, the better we will understand these experiences,” Newberg says. “We would like to [extend our work by] recruiting individuals who engage in Islamic and Jewish prayer as well as revisiting other Buddhist and Christian practices.”

Newberg and his colleagues discovered yet another activity pattern when they scanned the brains of five women while they were speaking in tongues — a spontaneous expression of religious fervor in which people babble in an incomprehensible language. The researchers announced in 2006 that the activity in their subjects’ frontal lobes—the entire front section of the brain—declined relative to that of five religious people who were simply singing gospel. Because the frontal lobes are broadly used for self-control, the research team concluded that the decrement in activity there enabled the loss of control necessary for such garrulous outbursts.

Spiritual Networking

Although release of frontal lobe control may be involved in the mystical experience, Beauregard believes such profound states also call on a wide range of other brain functions. To determine exactly what might underlie such phenomena, the Quebecois neuroscientist and his colleagues used fMRI to study the brains of 15 nuns during three different mental states. Two of the conditions — resting with closed eyes and recollecting an intense social experience — were control states against which they compared the third: reminiscence or revival of a vivid experience with God.

As each nun switched between these states on a technician’s cue, the MRI machine recorded cross sections of her brain every three seconds, capturing the whole brain roughly every two minutes. Once the neural activity was computed and recorded, the experimenters compared the activation patterns in the two control states with those in the religious state to elucidate the brain areas that became more energized during the mystical experience. (Although Beauregard had hoped the nuns would experience a mystical union while in the scanner, the best they could do, it turned out, was to conjure up an emotionally powerful memory of union with God. “God can’t be summoned at will,” explained Sister Diane, the prioress of the Carmelite convent in Montreal.)

The researchers found six regions that were invigorated only during the nuns' recall of communion with God. The spiritual memory was accompanied by, for example, increased activity in the caudate nucleus, a small central brain region to which scientists have ascribed a role in learning, memory and, recently, falling in love; the neuroscientists surmise that its involvement may reflect the nuns' reported feeling of unconditional love. Another hot spot was the insula, a prune-size chunk of tissue tucked within the brain's outermost layers that monitors body sensations and governs social emotions. Neural sparks there could be related to the visceral pleasurable feelings associated with connections to the divine.

And augmented activity in the inferior parietal lobe, with its role in spatial awareness — paradoxically, the opposite of what Newberg and Davidson witnessed — might mirror the nuns' feeling of being absorbed into something greater. Either too much or too little activity in this region could, in theory, result in such a phenomenon, some scientists surmise. The remainder of the highlighted regions, the researchers reported in the September 25, 2006, issue of Neuroscience Letters, includes the medial orbitofrontal cortex, which may weigh the pleasantness of an experience; the medial prefrontal cortex, which may help govern conscious awareness of an emotional state; and, finally, the middle of the temporal lobe.

The quantity and diversity of brain regions involved in the nuns' religious experience point to the complexity of the phenomenon of spirituality. "There is no single God spot, localized uniquely in the temporal lobe of the human brain," Beauregard concludes. "These states are mediated by a neural network that is well distributed throughout the brain."

Brain scans alone cannot fully describe a mystical state, however. Because fMRI depends on blood flow, which takes place on the order of seconds, fMRI images do not capture real-time changes in the firing of neurons, which occur within milliseconds. That is why Beauregard turned to a faster technique called quantitative electroencephalography (EEG), which measures the voltage from the summed responses of millions of neurons and can track its fluctuation in real time. His team outfitted the nuns with red bathing caps studded with electrodes that pick up electric currents from neurons. These currents merge and appear as brain waves of various frequencies that change as the nuns again recall an intense experience with another person and a deep connection with God.

Beauregard and his colleagues found that the most prevalent brain waves are long, slow alpha waves such as those produced by sleep, consistent with the nuns' relaxed state. In work that has not yet been published, the scientists also spotted even lower-frequency

waves in the prefrontal and parietal cortices and the temporal lobe that are associated with meditation and trance. "We see delta waves and theta waves in the same brain regions as the fMRI," Beauregard says.

Fool's Errand?

The brain mediates every human experience from breathing to contemplating the existence of God. And whereas activity in neural networks is what gives rise to these experiences, neuroimaging cannot yet pinpoint such activity at the level of individual neurons. Instead it provides far cruder anatomical information, highlighting the broad swaths of brain tissue that appear to be unusually dynamic or dormant. But using such vague structural clues to explain human feelings and behaviors may be a fool's errand. "You list a bunch of places in the brain as if naming something lets you understand it," opines neuropsychologist Seth Horowitz of Brown University. Vincent Paquette, who collaborated with Beauregard on his experiments, goes further, likening neuroimaging to phrenology, the practice in which Victorian-era scientists tried—and ultimately failed—to intuit clues about brain function and character traits from irregularities in the shape of the skull.

Spiritual neuroscience studies also face the profound challenge of language. No two mystics describe their experiences in the same way, and it is difficult to distinguish among the various types of mystical experiences, be they spiritual or traditionally religious. To add to the ambiguity, such feelings could also encompass awe of the universe or of nature. "If you are an atheist and you live a certain kind of experience, you will relate it to the magnificence of the universe. If you are a Christian, you will associate it with God. Who knows? Perhaps they are the same," Beauregard muses.

Rather than attempting to define religious experience to understand it, some say we should be boiling it down to its essential components. "When we talk about phenomena like a mystical experience, we need to be a lot more specific about what we are referring to as far as changes in attention, memory and perception," Davidson says. "Our only hope is to specify what is going on in each of those subsystems," as has been done in studies of cognition and emotion.

Other research problems abound. None of the techniques, for example, can precisely delineate specific brain regions. And it is virtually impossible to find a perfect so-called reference task for the nuns to perform against which to compare the religious experience they are trying to capture. After all, what human experience is just one detail different from the awe and love felt in the presence of God?

Making Peace

For the nuns, serenity does not come from a sense of God in their brains but from an awareness of God with them in the world. It is that peace and calm, that sense of union with all things, that Beauregard wants to capture — and perhaps even replicate. "If you know how to electrically or neurochemically change functions in the brain," he says, "then you [might] in principle be able to help normal people, not mystics, achieve spiritual states using a device that stimulates the brain electromagnetically or using lights and sounds."

Inducing truly mystical experiences could have a variety of positive effects. Recent findings suggest, for example, that meditation can improve people's ability to pay attention. Davidson and his colleagues asked 17 people who had received three months of intensive training in meditation and 23 meditation novices to perform an attention task in which they had to successively pick out two numbers embedded in a series of letters. The novices did what most people do, the investigators announced in June: they missed the second number because they were still focusing on the first—a phenomenon called attentional blink. In contrast, all the trained meditators consistently picked out both numbers, indicating that practicing meditation can improve focus.

Meditation may even delay certain signs of aging in the brain, according to preliminary work by neuroscientist Sara Lazar of Harvard University and her colleagues. A 2005 paper in NeuroReport noted that 20 experienced meditators showed increased thickness in certain brain regions relative to 15 subjects who did not meditate. In particular, the prefrontal cortex and right anterior insula were between four and eight thousandths of an inch thicker in the meditators; the oldest of these subjects boasted the greatest increase in thickness, the reverse of the usual process of aging. Newberg is now investigating whether meditation can alleviate stress and sadness in cancer patients or expand the cognitive capacities of people with early memory loss.

Artificially replicating meditative trances or other spiritual states might be similarly beneficial to the mind, brain and body. Beauregard and others argue, for example, that such mystical mimicry might improve immune system function, stamp out depression or just provide a more positive outlook on life. The changes could be lasting and even transformative. "We could generate a healthy, optimal brain template," Paquette says. "If someone has a bad brain, how can they get a good brain? It's really [a potential way to] rewire our brain." Religious faith also has inherent worldly rewards, of course. It brings contentment, and charitable works motivated by such faith bring others happiness.

To be sure, people may differ in their proclivity to spiritual awakening. After all, not everyone finds God with the God helmet. Thus, scientists may need to retrofit the

technique to the patient. And it is possible that some people's brains will simply resist succumbing to the divine.

Moreover, no matter what neural correlates scientists may find, the results cannot prove or disprove the existence of God. Although atheists might argue that finding spirituality in the brain implies that religion is nothing more than divine delusion, the nuns were thrilled by their brain scans for precisely the opposite reason: they seemed to provide confirmation of God's interactions with them. After all, finding a cerebral source for spiritual experiences could serve equally well to identify the medium through which God reaches out to humanity. Thus, the nuns' forays into the tubular brain scanner did not undermine their faith. On the contrary, the science gave them an even greater reason to believe.