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WHY LIGHT VISIONS ARE IMPORTANT FOR NEUROSCIENCE

Introduction

Decoding the Hidden Clues

The fundamental obstacle impeding progress in the scientific study of meditation is not a dearth of empirical data—there are many correlation studies that document changes in the brain during meditation—but there is still no comprehensive *causal* theory that can explain meditation in terms of the sequential activation of specific brain mechanisms. In this book I show that important clues about the identity of these neural mechanisms are *hidden in the data that have already been published.* The reason why investigators continue to overlook these hidden clues is that they do not have access to a conceptual framework that can reveal how new developments in the neuroscience of sleep, vision and epilepsy—developments that are generally regarded as unrelated to meditation—can be realigned to provide a simple, comprehensive and vertically-integrated causal theory of how the meditative state is installed and maintained. The key that makes it possible to reframe the conceptual landscape and to decode the hidden clues is a systematic, neurologically-grounded analysis of internally-generated light visions ("geometric phosphenes") that begin to flow spontaneously during the kind of "empty-mind" meditation practiced by experienced adepts in India and Tibet.

The sacred scriptures and yoga meditation treatises of India and Tibet describe these meditation-induced light visions as having predictable features that evolve in a predictable progression and culminate in ecstatic visions of lightning-

like flashes. The importance of understanding this phenomenon is underscored by the fact that many of the prominent scientific studies of expert meditators published in recent years have recruited Tibetan lamas as subjects. Often subjects are selected for their reputed mastery of the meditation techniques of "Highest Yoga Tantra" (*maha-anuttara-yoga*), and, to be more specific, on their ability to generate the phenomenon of "psychic heat" (*phumo*) that provides researchers with a clear and convincing physical sign of meditative prowess. The practice of Highest Yoga Tantra is based on a systematic cultivation of the same sequence of meditation-induced light visions that is the subject of the present investigation, a sequence that eventually produces lightning-like flashes and paroxysmal sensorimotor symptoms. This epileptiform outcome suggests the possibility that expertise in Highest Yoga Tantra instigates a neuronal kindling that gradually lowers the seizure threshold of those neuron assemblies in the visual pathways and in the temporolimbic complex that are regularly induced to fire in concert during meditation. If scientists are not aware of the mental strategies that the monks use in their advanced meditations, they are likely to encounter serious problems when it comes time to interpret their results and to compare their results with the findings reported by other studies that use different kinds of meditation techniques, especially if the subjects are novice meditators.

This book offers detailed, empirically-oriented descriptions of the spatial and temporal characteristics of meditation-induced light visions and proposes to answer this question: What kinds of neuronal events must take place at each stage of vision-processing in order for a phosphene image with the specified features to appear in the visual field of a meditator? The results of this investigation are dramatically more definitive than anyone might reasonably have expected at the outset—and I doubt that these results could be extrapolated by an independent review of the existing research literature.

The Neural Correlates of Light Visions

In recent years several books have been published in which scientists discuss science and meditation—books like James Austin's *Zen and the Brain* [MIT Press, 1999], Andrew Newberg and Eugene d'Aquili's *Why God Won't Go Away: Brain Science and the Biology of Belief* [Ballantine Books, 2001]; Richard Davidson and Anne Harrington's *Visions of Compassion: Western Scientists and Tibetan Buddhists Examine Human Nature* [Oxford University Press, 2002]; John Horgan's *Rational Mysticism: Dispatches From the Border Between Science and Spirituality* [Houghton Mifflin, 2003]; B. Allan Wallace's *Buddhism and Science* [Cambridge University Press, 2003]; Richard Dawkins' *The God Delusion* [Houghton Mifflin, 2006]; Daniel Dennett's *Breaking the Spell: Religion as a Natural Phenomenon* [Viking: 2006]; David Coming's *Did Man Create God: Is Your Spiritual Brain at Peace with Your Thinking Brain?* [2007]; and Beauregard and O'Leary's *The*

Spiritual Brain: A Neuroscientist's Case for the Existence of the Soul [2007]; and Anne Harrington and Arthur Zajonc's *The Dalai Lama at MIT* [2008]. All of these books address the subjects of brain science and religious mysticism in an interesting and informative manner, but none of them examines the particular phenomenon of meditation-induced light visions in any detail. If understanding light visions is the key that makes it possible to decode the nature of the brain mechanisms involved in meditation, as I propose, then all of these books have missed out on the most important and revealing phenomenon.

It is worth taking special notice of a comment by John Horgan, author of *Rational Mysticism*, who points out that only one of the many scientist-authors that he interviewed—all of whom are leading researchers in the field of neuroscience and religion—could actually say that he had himself experienced the kind of mystical event that was the subject of his scientific research. That single author is neurologist James Austin, author of *Zen and the Brain*. He describes his own mystical experiences in great detail and also ranges widely in his discussions of various mystical phenomena, but there's a catch. Since he practices Zen Buddhism, and since Zen actively discourages the cultivation of light visions, Austin's own experiences do not incorporate this particular phenomenon. While he does discuss light visions in passing, he can only rely on an outsider's perspective and thus is able to add little beyond what has already been written.

Reverse-Engineering the Author's Experiences

I'm a medical writer who specializes in writing technical videos for the continuing education of physicians. For many years I practiced meditation at irregular intervals, and often I would see two sets of geometric phosphenes, one following after the other in a predictable manner. These same phosphenes might also appear spontaneously if I were relaxing in bed, waiting for sleep to come. But if this were all I saw, I would not have begun the research that produced this book: what startled and intrigued me was a dramatic elaboration of the light vision sequence that occurred on one occasion when I inadvertently triggered a paroxysmal progression of phosphene images.

I had been suffering from insomnia—an unusual experience for me—and, as a result, I'd accumulated a substantial sleep deficit. I can be quite sure about the timing because I knew precisely when I got in bed and when I got out, and, by this criterion, I could not have slept for more than four of the preceding thirty-six hours. The night when the paroxysmal episode occurred, I found myself still awake and alert at four o'clock in the morning. I decided to get in bed and to meditate in the hope that this would induce enough relaxation for me to fall asleep. When I concentrated my attention in this sleep-deprived condition, the familiar light visions begin to flow. I noticed that the phosphenes seemed to be unusually bright, but then suddenly everything changed: the familiar geometric phosphenes I'd seen

on so many occasions were eclipsed by light visions that were much more dramatic and attention-riveting. These light visions evolved in an elaborate progression that culminated in lightning-like flashes, loud sizzling sounds, paroxysmal sensorimotor symptoms and an "ecstatic" emotional accompaniment.

This prolonged progression of light visions is seen only rarely and then only by religious mystics who are more interested in the metaphysical significance of the visions than in the neurological origins. So it is rarer still—and perhaps even unique—for someone with a scientific background and with no sectarian commitments to see these same visions. I can testify that the emotional experience was as powerful as the mystical texts suggest, but what caught my attention was the paradox that an ecstatic visionary rapture highly prized in the mystical traditions of India and Tibet had to be some kind of seizure. Was this really a *seizure*, and, if so, what kind of seizure? How it is possible for someone who has no symptoms of epilepsy to learn how to trigger this kind of ecstatic seizure and to do so at will? Do meditators who induce these light visions suffer any deleterious effects, and, if so, at what point does self-harm begin? Why is there little or no discussion of this paradoxical aspect of meditation in the medical research literature?

I prepared a set of schematic drawings to illustrate the salient characteristics of these internally-generated "phosphene" visions—their shapes, colors, movements, timing intervals and the order of appearance. Then I studied the latest research in the neuroscience of vision, sleep and epilepsy and used what I found to subject each phosphene image to a "reverse engineering" analysis. By systematically matching the structural characteristics of these phosphene images with the known activation patterns of various brain mechanisms, I was able to identify the precise mechanisms that would have to be activated in order for phosphene images with those characteristics to appear in the visual field. Based on this analysis and on the hypotheses it produced, I can now propose a simple, concrete and comprehensive *causal* theory that explains the neural origins of the behavioral state of meditation and of the phosphene images that appear during meditation. This theory generates a number of predictions amenable to empirical testing and also explains many of the contradictory and otherwise anomalous findings reported in the existing studies of meditators.

Reasoning that meditation must activate the same set of brain mechanisms no matter when or where it is practiced, and recognizing too that I needed to demonstrate that my own experiences were not merely idiosyncratic, I began to study the ancient yoga meditation texts of India and Tibet and autobiographical narratives of contemporary Hindu mystics. My prediction was that I'd find evidence of the same phosphene progression in most of the important meditation-related texts, and this was indeed the case—in Hindu and Tibetan sources [Nicholson, 2002a-c], in Chinese Daoist sources [Nicholson, 2008 & in press; Pfister, 2008], and in the literature on shamanistic practices, past and present [Nicholson, 2008; Nicholson and

Firnhaber, 2003]. Having a template of neurologically grounded drawings to serve as a standard for comparison, it becomes possible to decode references to self-induced light visions in textual passages and iconic representations that experts in the field have regarded too opaque and ambiguous to permit confident interpretation.

Methodological Issues in the Study of Meditation-Induced Qualia

This investigation must confront several methodological problems. First, introspective self-reports are generally regarded—with good reason—as being notoriously unreliable. Also, the subjective, "felt" qualities of a person's experience—the *qualia* of that experience—are generally considered to be epistemologically private and thus inaccessible to an "outside" observer. Finally, a serious methodological problem is posed when someone offers *ad hoc* (after-the-fact) explanations of any phenomenon: there are often several different, competing explanations that might conceivably account for the observed outcome, and the only scientifically-acceptable way of choosing among these alternatives is to conduct a disciplined hypothesis-testing program to sift the good explanations from the bad.

Unfortunately, all three of these methodological problems converge in this inquiry: I rely on *ad hoc* reasoning about introspective reports to generate my hypotheses, and I am not in a position to test the hypotheses myself. I also claim that my own subjective experiences of phosphene phenomena can be equated with written descriptions of visions which always involve some indeterminacy, and, what's worst, these descriptions were written by people who spoke different languages and lived in different cultures and historical epochs. In contemporary neuroscience, this kind of study would probably not be accepted for publication in a mainstream journal, even if it could somehow be compressed into an article-length format. How, then, can I reasonably expect that scientists will pay serious attention to the analyses I present in this book?

In the earliest stages of research in a scientific field, circumstances sometimes arise which require a relaxation of generally-accepted methodological standards in order to find ways to progress beyond the obstacles that pose barriers to further progress. Research on meditation, which is still in its infancy, falls within this exception. I've already mentioned one reason why that is so—the lack of a theoretical framework—but equally important is the fact that the most precise measuring instruments currently available have significant limitations when applied to meditation research. In particular, these instruments have not yet achieved the resolution needed to probe effectively into the complex and intricately-interconnected circuits of the very small neuron assemblies that have been implicated by my phosphene analysis as key participants in establishing a meditative state, for example, the lateral geniculate nucleus (LGN), the thalamic reticular nucleus (RTN) and the hippocampal complex. And there are other problems as well, including these issues

noted by Dr. Andrew Newberg, the radiologist responsible for organizing many of the more advanced and well-regarded studies of meditators that use PET, SPECT and fMRI technologies:

> There are other more global problems that affect the ability to interpret the results of all functional neuroimaging studies. The most important of these is how to be certain what is actually being measured physiologically and how it compares to various subjective experiences. There are already potential problems addressing what a particular scan finding means in terms of the actual activity state of the brain. . . . A bigger problem is trying to compare the observed physiological changes to the subjective state. With regard to religious and spiritual experience, it is not possible to intervene at some "peak" experience to ask the person what he or she is feeling. Therefore, . . . how will the researcher know which scan findings it relates to? In addition, there are typically a number of changes in the brain with varying degrees of strength. It is not clear what degree of change should be considered a relevant change—10 percent? 20 percent? [Newberg and Lee, 2005, p. 477].

The analysis of meditation-induced phosphenes provides a way of sidestepping the limitations in the resolution of neuroimaging instruments and in the interpretation of the results. This analysis focuses the attention of researchers on certain specific neuronal circuits, and it moves far beyond what would be possible using radionucleide imaging by revealing how neuronal events evolve over time—how pre-ictal events potentiate lowered seizure thresholds; how different kinds of paroxysmal activity are triggered and how they propagate; and how the variety of post-ictal sequelae provide retrospective evidence about what kinds of excitotoxic damage must have been caused by the meditation-induced ecstatic seizure.

As for the question of whether or not it is legitimate for scientists to study the neural correlates of consciousness by analyzing subjective qualia, I'd like to cite the comments of neuroscientist Gerald Edelman, creator of the influential theory of Neural Darwinism, who writes that "It is our ability to report and correlate while individually experiencing qualia that opens up the possibility of a scientific investigation of consciousness [Edelman, 1992, p. 115]." Reports of qualia can be "discriminated in terms of modality, intensity, continuity, or their temporal or spatial properties," and these kinds of discriminations can provide useful information about "the actual mechanisms by which qualia arise [Ibid., p. 116]." My investigation of the shapes, colors, movements, timing intervals and sequences of meditation-induced light visions, all of which are generated by wholly internal processes, constitutes a good example of what can be accomplished by following Edelman's advice.

That a seizure-like event is implicated here may present a special advantage. In an article entitled "Consciousness, epilepsy and emotional qualia," Monaco et al. [2005] suggest that seizure-associated qualia represent "a privileged window into the neural bases of consciousness" because many qualitative aspects of seizure-driven experiences are associated with specific kinds of neuronal events

that are known to be localized in the temporolimbic system. Epileptiform temporolimbic discharges are often proposed as likely causes of the anomalous psychic and emotional experiences documented in the literature of religious mysticism. Research psychologist Michael Persinger [1987] was an early proponent of the theory that many kinds of psychic phenomena and mystical religious experiences are the products of "temporal lobe transients" [Persinger, 1987]. More recently psychiatrists Jeffrey Saver and John Rabin [1997] have proposed a "limbic marker hypothesis" as the most likely explanation for a variety of anomalous experiences that are commonly regarded as "mystical:" in their view, the contents of a person's perception, cognition, and emotion at some specific time can be suddenly and dramatically transformed by momentary eruptions of abnormal discharges in the temporolimbic system that have the effect of "tagging" those erstwhile ordinary experiences with a sense that these events, far from being ordinary, were exceptional and deeply meaningful. This emotional embellishment of the contents of everyday experience are then preserved in the person's memories of the event. The limbic marker thesis can explain why many of the psychic symptoms described by religious mystics are also known to be associated with temporal lobe disturbances:

> The core qualities of religious and mystical experience . . . are the noetic and ineffable—the sense of having touched the ultimate ground of reality and the sense of the unutterability or incommunicability of the experience. Frequent additional features are an experience of unity, an experience of timelessness and spacelessness, and a feeling of positive affect, of peace and joy. We suggest that the primary substrate for this experience is the limbic system. Temporolimbic discharges can produce each of these components in fragmentary or complete form: distancing from apparent reality (depersonalization, derealization), timelessness and spacelessness (autoscopy, time distortion), or positive affect (ecstatic auras) / The limbic system integrates external stimuli with internal drives and is part of a distributed neural network that marks stimuli and events with positive or negative value. . . . Moreover, in addition to simple positive or negative valence, limbic discharges can produce experiences that are intermediate between customary divisions between affects and cognition. For example, "a sense of familiarity" arises in the limbic system as a quasi-emotional marker of experience. Usually the limbic familiarity jibes with explicit recall, but it can appear discordantly, producing déjà vu or jamais vu experiences. We suggest that, similarly, limbic discharges may mark experiences as (1) depersonalized or derealized, (2) crucially important and self-referent, (3) harmonious -indicative of a connection or unity between disparate elements, and (4) ecstatic - profoundly joyous. This limbic activity underlies certain psychic seizure auras, near-death experiences, and religious and mystical experiences of normal individuals [Saver and Rabin, Ibid., p. 204].

The two psychiatrists predict that researchers will soon be able to detect the presence of these abnormal temporolimbic perturbations as newer instruments capable of making more refined measurements of internal brain processes become available. But what can neuroscientists hope to accomplish while they're waiting for the advent of this new technology? And when those new instruments become

available, where in the brain are the scientists most likely to find what they're looking for?

Information produced in the analysis of the structural and temporal characteristics of meditation-induced phosphenes can help neuroscientists plot a research strategy that maximizes the chances of making important new discoveries. The phosphene analysis presented in this book identifies the precise nature of the abnormal temporolimbic activity that Saver and Rabin predict will be identified once new technology becomes available—and the phosphene evidence is available now. The "reverse-engineering" of the meditation-induced phosphene images reveals that the final event in a predictable progression is the outbreak of a simple partial seizure of hippocampal (temporolimbic) origin accompanied by psychic symptoms that definitely qualify as "ecstatic," even under the most restrictive definition of that label. But what makes the phosphene analysis especially valuable is the insight it provides into *how events at the neurological level unfold as time elapses*: as the subject begins to meditate, the initial changes in brain wave patterns associated with a tranquil meditative state give way to brain wave patterns associated with an outbreak of abnormal discharges, then further changes in phosphene elements allow the spread of paroxysmal activity to be traced from thalamocortical circuits to the hippocampus and then through the subregions of the hippocampus and out into the adjacent mesotemporal cortices. These insights are otherwise unobtainable, given existing equipment, and they will almost certainly continue to be invaluable in the future, even after better equipment becomes available, for those researchers who design empirical studies of meditation.

The Sleep Rhythm Theory of Meditation

The theory I propose, based on my analysis of phosphene imagery, is that meditators learn how to manipulate the neural mechanisms that normally govern the transition from waking to slow wave sleep. In normal circumstances the activation of the synchronous sleep rhythms of "stage 2" non-rapid-eye-movement sleep (NREMS) would induce the familiar loss of consciousness that begins at sleep onset, but meditators can learn how to manipulate eye position and attentive focus so that they keep visual consciousness intact. As the synchronous sleep rhythms of stage 2 NREMS are relayed through the visual cortices (as would happen even if consciousness had been lost), the meditation-stimulated neurons in the primary visual cortices receive and process these signals as if they were afferent visual signals—and, as a result, the meditator sees a phosphene image.

When meditation is restricted to calm contemplation, the phosphene images are generated by synchronous sleep rhythms reverberating back and forth between the thalamus and the visual cortices, but meditators can learn to provoke a destabilization of sleep rhythm oscillators that triggers a sudden, discontinuous change in the kinds of phosphene images they see: instead of the "sleep rhythm"

phosphenes, they see images that display a more forceful, "driven" quality and that are accompanied by paroxysmal sensorimotor symptoms. I trace this shift in phosphene imagery to the outbreak of hypersynchronous activity in corticothalamic circuits similar to what happens during absence seizures, but the incipient absence-like seizure does not generalize in this situation (probably because inhibitory mechanisms remain intact in the normal brain). What happens next is a build-up of rhythmical activity in the hippocampus driven by the hypersynchrony in corticothalamic circuits, and this build-up of rhythmical activity eventually triggers an outbreak of paroxysmal discharges that the phosphene evidence attributes to a specific and spatially-restricted region of the contralateral hippocampus. The analysis of phosphene imagery shows the evolution of these events, second-by-second, revealing where paroxysmal discharges begin inside the hippocampus and how they propagate from one intrahippocampal circuit to the next. The culminating event that underlies the ecstatic visions of lightning-like flashes, strange sensorimotor currents, and psychic symptoms of euphoria and ecstasy is a rare type of simple partial temporolimbic seizure of hippocampal origin.

If my theory is correct in explaining what takes place in the temporolimbic structures of the brain when meditators claim to have induced a "peak ecstasy," then one should be able to find evidence of a shift to paroxysmal activity in the published studies of advanced meditators. Does such evidence exist? I'm confident that it does, especially in the more recent EEG studies that generate topological maps of dominant brain wave frequencies—and the book contains a chapter dedicated to exploring this claim.

The possibility of a link between slow wave sleep and meditation has begun to attract the attention of neuroscientists. In a recent study of hypnotized subjects, Rainville et al. [2003] used PET scans in conjunction with a cortical EEG to compare the changes in cerebral activity measured by these different instruments. The researchers found significant increases in blood flow to the occipital cortices at a time when delta activity was prominent in the scalp EEG, "a pattern similar to the results obtained in slow wave sleep [Rainville et al., Ibid., p. 116]." Based on their findings, they propose "a state theory of hypnosis in which occipital increases in rCBF and delta activity reflect the alteration of consciousness associated with decreased arousal and possible facilitation of visual imagery [Ibid., p. 110]." This is the first PET study that I'm aware of which identifies slow wave sleep rhythms as potentially important in the generation of hypnotic trance states, but if my sleep rhythm activation theory is correct, this will be only the first of many.

Is There a "God Module" in the Brain?

A provocative question was posed to an audience of neurologists at the annual meeting of the Society for Neuroscience in New Orleans in 1997: V. S. Ramachandran suggested that humans may have "specialized neural circuitry for

the sole purpose of mediating religious experience," a comment that led journalists who attended the meeting to report that neurologists were speculating about the existence of a "God module" [Bower, *Science News* 2001;159(97): 104 – 106]. The Ramachandran experiment that gave rise to this remark was a minor one: it was a demonstration that patients with temporal lobe epilepsy who listened to words with religious connotations had stronger galvanic skin responses than did normal volunteers [Ramachandran and Blakeslee, 1997]. The researchers were not in a position to identify the specific brain mechanisms involved based on their data.

My analysis of meditation-induced phosphenes suggests that there is a set of neural mechanisms that can occasionally function as a "god module," but the analysis reveals that these mechanisms, as they manifest in clear light visions, are not "specialized . . . for the sole purpose of mediating religious experience," as Ramachandran suggested, but rather these are the very same mechanisms that put humans to sleep at night. This insight demonstrates that the mundane can be transformed, temporarily, into a vehicle of transcendence—into a "god module."