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CHAPTER 19

Meditation and the Neuroscience of Consciousness: An Introduction

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Abstract

The overall goal of this chapter is to explore the initial findings of neuroscientific research on meditation; in doing so, the chapter also suggests potential avenues of further inquiry. It has three sections that, although integral to the chapter as a whole, may also be read independently. The first section, "Defining Meditation," notes the need for a more precise understanding of meditation as a scientific explanandum. Arguing for the importance of distinguishing the particularities of various traditions, the section presents the theory of meditation from the paradigmatic perspective of Buddhism, and it discusses the difficulties encountered when working with such theories. The section includes an overview of three practices that have been the subject of research, and it ends with a strategy for developing a questionnaire to define more precisely a practice under examination. The second section, "The Intersection of Neuroscience and Meditation," explores some scientific motivations for the neuroscientific examination of meditation in terms of its potential impact on the brain and body of long-term practitioners. After an overview of the mechanisms of mind-body interaction, this section addresses the use of first-person expertise, especially in relation to the potential for research on the neural counterpart of subjective experience. In general terms, the section thus points to the possible contributions of research on meditation to the neuroscience of consciousness. The final section, "Neuroelectric and Neuroimaging Correlates of Meditation," reviews the most relevant neuroelectric and neuroimaging findings of research conducted to date, including some preliminary correlates of the previously discussed Buddhist practices.

Introduction

This chapter discusses possible contributions of meditation to the neurobiological study of consciousness and to cognitive and affective neurosciences in general. Empirical research on meditation started in the 1950s, and as much as 1,000 publications on meditation already exist.[1] Despite such a high number of scientific reports and inspiring theoretical proposals (Austin, 1998; Shapiro & Walsh, 1984; Varela, Thompson, & Rosch, 1991; Wallace, 2003; West, 1987), one still needs to admit that little is known about the neurophysiological processes involved in meditation and about its possible long-term impact on the brain. The lack of statistical evidence, control populations and rigor of many of the early studies; the heterogeneity of the studied meditative states; and the difficulty in controlling the degree of expertise of practitioners can in part account for the limited contributions made by neuroscience-oriented research on meditation. Thus, instead of providing a complete review of this empirical literature (Austin, 1998; Cahn & Polich, 2006; Delmonte, 1984, 1985; Fenwick, 1987; Holmes, 1984; Pagano & Warrenburg, 1983) we choose to address our central question from three directions.

The purpose of this first section is to clarify conceptually what the term "meditation" means and to propose an operational definition. We focus on Buddhist meditative practices as a canonical example. We provide a short presentation of the main tenets of Buddhist psychology and epistemology, as well as a description of the standard techniques used in many Buddhist practices. From these standard claims, we then derive the possible contributions of meditation to neurosciences and develop tentative proposals for a neuroscientific understanding of the cognitive and affective processes that are altered by training in meditation. In the last section, we review existing neuroelectric and neuroimaging findings on meditation, as well as some preliminary correlates of these Buddhist practices.

1. Defining Meditation

Although widely used, the term "meditation" is often employed in a highly imprecise sense such that its descriptive power is greatly decreased. One underlying reason for the term's inadequacy is that, in its typical usage, it refers generically to an extremely wide range of practices. Thus, in a typical discussion of this kind, West (1987) argues that practices as diverse as the ritual dances of some African tribes, the spiritual exercises of the desert fathers, and the tantric practices of a Tibetan adept are all forms of meditation. Historically, this attempt to categorize diverse practices under the same rubric reflects some intellectual trends in the early 20th century, most especially "perennialism," that argue unequivocally for a certain genre of mystical experience as the essence of religion (Proudfoot, 1985; Sharf, 1998). From the standpoint of the neurosciences, the problem with such a position is that it begins from a set of hypotheses that are difficult to test because they assume that the common element in mystical experience necessarily transcends thought, language, reason, and ordinary perception – most of which are required for any reliable neuroscientific procedure to test the hypotheses.

In addition to the problem of unverifiable hypotheses, the generic use of meditation as applying to such a wide range of diverse practices inevitably trivializes the practices themselves. For example, the unique techniques and context of Sufi *zikr* must be ignored if they are to be considered the same as the Taoist practice of T'ai Chi. In short, to make *zikr* and T'ai Chi describable with the same term, one must ignore a good deal of what makes them radically different from each other. This would be akin to the use of the word "sport" to refer to all sports as if they were essentially the same. A typical result of such an approach is the extremely general model proposed by Fischer (1971) in which all forms of meditation – exemplified by Zazen and some unspecified "Yoga" practice – fall along the same trophotropic scale of hypoaraousal, even though attention to the details of many Buddhist practices, including Zazen (Austin, 1998), makes a description in terms of hypoarousal extremely problematic.

An alternative approach to research on meditation is to attend more closely to the particularity of the individual practices in question. An apt metaphor in this case might be the interaction between traditional medical systems and researchers seeking to develop new pharmaceuticals. In their search for plants whose active ingredients might yield effective new medications, some researchers have begun examining traditional medical systems in various cultures in order to narrow their search based on traditional claims about the medicinal properties of local plants (Jayaraman, 2003; Schuster, 2001). In that collaboration, attention to the particularity of the healing tradition is crucial, for it is the local knowledge about specific, local plants that will aid the search for new medications. Clearly, such a project would be gravely hindered if researchers were to assume that, for example, an Amazonian healer's traditional herbal lore would somehow amount to the same traditional knowledge about medicinal herbs that one would hear from a Himalayan healer. The value of consulting a specific tradition is precisely that – through accident or expertise – the tradition may have gleaned some valuable knowledge or developed some practice that is not found elsewhere. This importance of particularity supports the need to preserve local traditions, but it also speaks to the need to heed their boundaries. A common problem with the literature on meditation is a tendency to ignore those boundaries in order to emphasize some vague universality in human experience.

This attention to the particularity of contemplative traditions is related to another aspect of the approach we adopt; namely, that it is also strongly consistent with our knowledge of the neurosciences. Specifically, cognitive and affective neuroscience has matured over the past decade, and we now understand something about the brain mechanisms that subserve different attentional and affective processes. Meditation techniques that target specific underlying processes are thus likely to engage different neural circuitry. If, however, the particularity of a tradition's claims and practices are not examined, the possibility that a practice targets a specific process will not be noted.

Sorting Claims and Descriptions

In emphasizing the particularity of each tradition's approach to meditation, one need not discount the possibility that highly disparate traditions may have independently developed techniques that lead to similar and measurable outcomes.[2] Nevertheless, it seems best not to begin with an assumption about any such innate similarity in disparate meditative traditions. One reason for avoiding such assumptions is the issue of particularity above, but another reason is that similarities among traditions tend to appear primarily in claims about the ultimate meaning or nature of the state attained (e.g., "pure consciousness") or in metaphysically charged phenomenological descriptions (e.g., ineffability) that do not lend themselves to easy measurement or interpretation.

Because similarities among traditions often rest on such issues, an emphasis on those similarities tends to exaggerate a problem that all researchers on meditation must face; namely, the need to discern which parts of a traditional account of meditation are useful in formulating a neuroscientific research strategy, as opposed to parts of an account that are not suitable for that purpose. The problem here is the need to interpret traditional discourse about meditation, especially in terms of meditative techniques and resultant states. In short, traditional accounts often describe techniques and resultant states that are measurable and repeatable; nevertheless, parts of the same account may also focus on issues that can neither be measured nor repeated. In many traditions, the distinction between these parts of an account reflects a tension between (1) close descriptions of meditative techniques and states and (2) the metaphysical or soteriological requirements that must be met by those states, often expressed in textual sources that the tradition considers inviolable.

Let us take as an example the Tibetan practice of "Open Presence," which we discuss further below. In describing Open Presence, traditional authors, such as Wangchug

Dorjé (1989) and Thrangu (Thrangu & Johnson, 2004), offer typically detailed descriptions both of the techniques that induce that state and also of the experiences that should occur when the techniques are applied properly.[3] For example, discursive techniques for de-emphasizing the objectification of sensory content are described in detail, and in terms of resultant states, the consequent loss of a sense of subject-object duality is also articulated clearly. These parts of the traditional account lend themselves to investigation, inasmuch as they describe techniques and results for which neural correlates may be plausibly postulated and tested. At the same time, however, Buddhist philosophical concerns also demand that the state of open presence reflects the ontological foundation of all reality, and Buddhist notions of nirvāṇa also require that the realization of that state will lead the adept to attain inconceivable physical and mental powers. Such claims often occur in texts that traditional scholars are obliged to defend under all circumstances. From a neuroscientific perspective, however, these claims do not lend themselves readily to analysis or description. Thus, from the vantage point of the researcher who stands outside the tradition, it is crucial to separate the highly detailed and verifiable aspects of traditional knowledge about meditation from the transcendental claims that form the metaphysical or theological context of that knowledge.

Meditation as Explanandum

Attention to the particularity of each tradition and the careful examination of traditional knowledge about meditation both contribute to a main concern of this chapter: the notion of meditation as an explanandum. Or, to put the issue another way, how does one define "meditation" in the context of neuroscientific study? This question is not answered easily in part because of the extremely wide variety of human activities to which the term "meditation" might be applied. And the situation may not be much improved even if one focuses on just one tradition. In the case of Buddhism, most traditions use a term for meditation that correlates with the Sanskrit term *bhāvanā*, literally, "causing to become." In Tibetan traditions, the usual translation for *bhāvanā* is *gôm (sgom)*, which roughly means "to become habituated to" or "to become familiar with." The meditative traditions of Tibetan Buddhism often employ the term in a generic fashion, and as a result, it is often translated into English with the equally generic term "meditation." The generic usage of *gôm* or "meditation" reflects its application to a remarkably wide range of contemplative practices: For example, the visualization of a deity, the recitation of a mantra, the visualization of "energy" flowing in the body, the focusing of attention on the breath, the analytical review of arguments or narratives, and various forms of objectless meditations would all be counted as "meditation."

Nevertheless, despite this variety, it is possible to identify some relevant features common to the traditional descriptions of these Buddhist practices, especially when one separates those descriptions from metaphysical arguments or exigencies that stem from defending a textual tradition. First, it is assumed that each such practice induces a predictable and distinctive state (or set of states) whose occurrence is clearly indicated by certain cognitive or physical features or events phenomenally observable to the practitioner. Second, the state induced is said to have a predictable effect on both mind and body in such a way that, by inducing that state repeatedly, a practitioner can allegedly use it to enhance desirable traits and inhibit undesirable ones. Third, the practices are gradual in the sense that the ability to induce the intended state is supposed to improve over time, such that an experienced practitioner should meditate in a manner that is superior to a novice. From the traditional standpoint, this improvement is marked especially by two phenomenally reportable features: the acquisition of certain traits (cognitive, emotional, or physical) and/or the occurrence of certain events (cognitive, emotional, or physical). Finally, the practice used to induce the state must be learned, usually from a meditation teacher who is said to be a virtuoso in the practice. That teacher will also serve as a guide to the practice so as to assist the practitioner in improving his or her ability to produce the state.

Based on these features, these diverse forms of Buddhist meditation may be taken as explananda in regard to three general issues: (1) the claimed production of a distinctive and reproducible state that is phenomenally reportable, (2) the claimed relationship between that state and the development of specific traits, and (3) the claimed progression in the practice from the novice to the virtuoso. Although initially formulated in terms of Tibetan practices, these features seem to be a useful way of understanding how meditative practices in most contemplative traditions may be construed as neuroscientific explananda.

A Paradigmatic Framework: Buddhist Meditative Techniques

Our use of Buddhist contemplative traditions to develop a theoretical framework for understanding meditation is not merely a product of historical accident; rather, Buddhist contemplative traditions are particularly well suited to the development of this kind of theoretical model. The reason, in brief, is that unlike many contemplative traditions, Buddhist traditions tend to offer extensive, precisely descriptive, and highly detailed theories about their practices in a manner that lends itself readily to appropriation into a neuroscientific context. This emphasis on descriptive precision stems from the central role that various forms of meditation play in Buddhist practice. That is, from the standpoint of nearly every Buddhist tradition, some type of meditative technique *must* be employed if one is to advance significantly on the Buddhist spiritual path, and because Buddhism initially developed in a cultural context where a wide range of such techniques were available, Buddhist theoreticians recognized the need to specify exactly the preferred techniques. Their analyses eventually develop into a highly detailed scholastic tradition known in Sanskrit as the *Abhidharma* – a type of Buddhist "psychology" that also includes discussions of epistemology, philosophy of language, the composition of the material world, and cosmology.[4]

Despite the variety of Buddhist traditions, they share two axioms articulated in *Abhidharma* texts: A central goal of Buddhist practice is the elimination of suffering, and any effective method to eliminate suffering must involve changes in one's cognitive and emotional states, because the root cause of suffering is a set of correctable defects that affect all the mental states of an untrained person (Gethin, 1998). Thus, any practice that is considered by the tradition to be an effective method must involve the features noted above, including some set of reliable techniques that induce mental states that will induce the desired changes in behavioral and psychological traits. In this regard, the Buddhist contemplative traditions exhibit considerable diversity, because they hold divergent opinions about the precise nature of the defects to be eliminated, the traits to be induced, and the best methods for accomplishing all this. At the same time, both the diversity and the continuity of Buddhist contemplative practices also stem from the rich cultural context in which Buddhism initially flourished.

EARLY HISTORY AND BASIC FORMS

When the historical Buddha Śākyamuni first set out on the religious life (ca. 500 BCE), he apparently encountered a large number of meditative techniques that were already being practiced by various contemplative traditions in South Asia. Although historical sources from this period are generally vague in their descriptions of contemplative practices, one can identify some common trends. Broadly speaking, these traditions maintained that the contemplative life should be focused on the search for one's true self (often called the *ātman*), and because this true self was generally assumed to be somehow obscured by one's involvement in the world of the senses, many contemplative techniques involved an inward focus whereby one's mind was retracted from the senses. In addition to this inward focus, most techniques from this period probably sought to reduce the occurrence of other types of mental content – generically called "conceptuality" *(kalpanā)* – that were also thought to obscure one's vision of the true self. Distractions caused by the fluctuation of the mind were commonly thought to be linked to the fluctuation of the breath, and meditative techniques therefore often involved either breath control *(prāṇāyāma)* or at least some attention to the disposition of the breath. And because the mind was thought to be strongly influenced by the body, contemplative practices involved specific postures or corporeal exercises (Bronkhorst, 1986; Gethin, 1998).

When these practices were appropriated by the historical Buddha Śākyamuni, their overall context was altered, inasmuch as the Buddha maintained that the belief in a "true self" *(ātman)* was completely mistaken. Indeed, from the earliest days a central goal of Buddhist contemplative practice is precisely to demonstrate to the practitioner that no such fixed or absolute identity could ever be possible (Gethin, 1998). Nevertheless, although the Buddha altered the context of the contemplative practices that he encountered, the Buddhist meditative techniques that he and his followers developed retained some of the same basic principles of inward focus, reduction of conceptuality, the importance of the breath, and the relevance of the body.

Perhaps the most ubiquitous style of Buddhist meditation that exhibits these features is meditation aimed at improving concentration – a style of meditation that is rooted in practices aimed at obtaining *śamatha*. Translatable literally as "quiescence," *śamatha* is a state in which the practitioner is able to maintain focus on an object for a theoretically unlimited period of time. As a term, *śamatha* therefore can also describe one of the historically earliest and most basic styles of Buddhist meditation that aims at attaining that state. In such a practice, the practitioner augments especially a mental faculty known as *smṛti*, confusingly translated as both "mindfulness" and "awareness"; in simple terms, it is the mental function *(caittāsika)* that focuses the mind on an object. At the same time, the meditation involves a faculty that checks to see whether the *smṛti* is focused on the intended object or whether it has lost the object. Thus, this other faculty, often called *samprajanya*, involves a type of meta-awareness that is not focused on an object per se, but rather is an awareness of that intentional relation itself (Gethin, 1998; Silananda, 1990; Wallace, 1999).

Both as a state and as a style of practice, *śamatha* provides the practical and theoretical underpinnings of many other Buddhist practices, especially because it constitutes the basic paradigm for any practice that involves one-pointed concentration *(ekāgratā)* on a specific object. At the same time, however, Buddhist theorists who discuss *śamatha* generally do not consider it to be in and of itself Buddhist. That is, practices oriented toward attaining *śamatha* must create a highly developed ability to sustain intense focus on an object, and whereas the development of that ability does lead to some trait changes, it does not lead to all of the changes that Buddhists seek, most especially in regard to the regulation of emotions. Hence, although a *śamatha*-oriented practice may be a necessary ingredient of most Buddhist contemplative traditions, it must be accompanied by another fundamental style of Buddhist practice; namely *vipaśyanā* or "insight." (Gethin, 1998; Silananda, 1990; Wallace, 1999).

As with the *śamatha* style of practice, *vipaśyanā* is also one of the earliest and most fundamental forms of meditation. For Buddhist theorists, *vipaśyanā* is a style of meditation that, in combination with the focus or stability provided by cultivating *śamatha*, enables the practitioner to gain insight into one's habits and assumptions about identity and emotions. In general, this insight includes especially the realization of "selflessness" *(nairātmya)* – that is, realizing that one's belief in a fixed, essential identity is mistaken and hence that the emotional habits that reflect that belief are baseless (Dalai Lama XIV, 1995; Gethin, 1998; Silananda, 1990). Nevertheless, although every Buddhist contemplative tradition would agree that such a realization must be part of *vipaśyanā*, one again encounters considerable diversity in the precise way in which *vipaśyanā* is defined and the way it is developed in practice. For example, in some traditions reasoning and a type of internal conceptual discourse are critical to the practice, but other traditions maintain that reason and concepts are of only limited use in obtaining *vipaśyanā*. Likewise, some traditions maintain that a *vipaśyanā* meditation must have an object toward which some type of analysis is brought to bear (Dalai Lama XIV, 1995; Silananda, 1990), whereas others maintain that the meditation must eventually become completely objectless (Wangchug Dorjé, 1989). Perhaps the sole theme that runs throughout all Buddhist traditions is that, in *vipaśyanā* meditation, the type of meta-awareness mentioned earlier plays an especially important role – an issue that we examine in the section on the theory of meditation.

FURTHER HISTORICAL DEVELOPMENTS

Although the basic combination of *śamatha* and *vipaśyanā* provides both a theoretical and historical touchstone for the development of Buddhist contemplative practices, a number of other forms of meditation were developed in the various Buddhist communities of Asia. Three practices initially developed in India are especially emblematic of the range of developments: "Recollection of the Buddha" meditations *(buddhānusmṛti)*, Lovingkindness meditation *(maitrībhāvanā)*, and tantric "Wind" *(vāyu)* meditations.

The practice of Recollection of the Buddha is probably, along with Lovingkindness meditation, one of the oldest Buddhist practices. Recollection involves the recitation of the Buddha's attributes, and in its earliest form it may have involved nothing more than that. At some point, however, the recitation of the Buddha's physical attributes was linked with the visualization of the Buddha in the space in front of the practitioner. This basic technique of recitation and visualization is representative of a wide range of similar Buddhist practices that evolved during the first millennium. Chief among these is the practice of visualizing deities and paradisiacal environments, a technique especially important in most forms of Buddhist tantra (Beyer, 1977).

Alongside Recollection (and later, visualization) practices, Lovingkindness meditation was also a widespread practice in both early and later Buddhism, where it is thematized as the cultivation of "great compassion" *(mahākaruṇā)*. The practice aims to cultivate an emotional state; namely, a sense of love and compassion toward all living things. Representative of a wide range of practices that promote or inhibit traits by repeatedly inducing a particular emotional state, some forms of the practice involve the recitation/visualization techniques employed in Recollection meditation. Some discursive strategies, such as thinking through the steps of an argument for compassion, may also be employed (Dalai Lama XIV, 1991; P. Williams, 1989).

Last to develop (toward the end of the first millennium in India) are a variety of practices that may be called tantric Wind meditations. These practices aim to manipulate the various forms of energy, metaphorically called Wind *(vāyu)*, that are alleged to flow in channels throughout the body. This model is roughly analogous to the contemporary understanding of the nervous system, where the notion of Wind is analogous to the propagation of neural impulses. In the Buddhist model, the mind itself is thought to consist of such Wind energy, and practices that manipulated that energy were therefore intended to induce or inhibit mental states or traits. The many techniques employed include the visualization of various syllables or other items at specific points in the body as a means to alter the flow of mental energy; physical exercises, including breathing exercises; and an array of other techniques, including manipulation of the diet. An example of this style of practice that later becomes important in Tibet is the "Tummo" *(gtum mo)* practice – a method that, in manipulating the Wind, is also said to generate considerable body heat as a byproduct (Cozort, 1986; Dalai Lama XIV, 1995; English, 2002; Snellgrove, 2002).

As Buddhism spread from its initial location in the Gangetic plain, Buddhist practitioners developed and enhanced the above practices, along with many other related forms of meditation. Eventually, Buddhism spread to other regions of Asia, and various traditions arose that persist to this day. Each tradition elaborated its own particular interpretation of techniques that, although likely inherited from Indian Buddhist traditions, always acquired a local flavor. Nevertheless, most extant practices reflect the various styles of meditation noted above.

ANALYSIS OF MEDITATION: SAMATHA AND VIPAŚYANĀ AS PARADIGM

To aid in the mastery of meditative techniques – and also to respond to critics outside their traditions – Buddhist theoreticians in India and elsewhere developed detailed accounts of their contemplative practices. These accounts are often extremely complex, and as noted above, they sometimes raise metaphysical issues that are not easily addressed in neuroscience. Likewise, to some degree the accounts are shaped by the need to defend a particular textual tradition or line of argumentation, and as a result, some statements that seem to be descriptive are not known to be exemplified by any actual Buddhist practice. Nevertheless, other aspects of the accounts seem more empirical in their approach, and attention to those aspects may prove useful when examining meditation in a laboratory context. With this in mind, we have sketched the following practical and simplified account of Buddhist meditation theory, aimed especially at researchers interested in studying contemplative practices in Buddhism and other traditions. As one might expect, the numerous forms of Buddhist meditation are accompanied by an equally wide range of theoretical accounts. Nevertheless, the central issues can be addressed in terms of the theories that undergird *śamatha* and *vipaśyanā*, especially when these styles of meditation are understood to describe *two aspects of the same meditative state*. In the interest of both applicability and simplicity, we derive our account primarily from a specific and living contemplative tradition: Tibetan Buddhism.

Drawing on a maxim developed by their Indian predecessors, Tibetan theorists maintain that the highest forms of Buddhist meditation must integrate the qualities of *śamatha* and *vipaśyanā* into a single practice. As described by the most common traditional metaphor, the practitioner cannot make significant spiritual advancement without the combination of *śamatha* and *vipaśyanā*, just as a cart cannot move without two wheels. Another traditional metaphor is perhaps more descriptive: When attempting to see the murals on the wall of a dark cave, one must use a lamp that is both well shielded and bright. If the lamp is not well shielded, then its flame will flicker or even become extinguished, and if its flame is not sufficiently intense, the lamp's light will be insufficient for the task at hand (Tsongkhapa, 2002). This very basic metaphor describes the qualities that are indicated by the terms *śamatha* and *vipaśyanā*: The former primarily concerns the stability *(gnas cha)* of the meditative state, whereas the latter concerns that state's phenomenal or subjective intensity *(gsal cha)* (Thrangu & Johnson, 2004).

To state these features more precisely, in meditations that involve an object, stability refers to the degree to which the practitioner is able to retain focus on the object without interruption. In such meditations, clarity refers to the sharpness or vividness of the appearance of the object in awareness. For example, in the visualization of a colored disc, a completely stable meditation would be one in which the meditator's focus on the object is not perturbed at all by other phenomenal events, such as emotions, thoughts, or sensory perceptions. In such a meditation, the clarity would be constituted by the disc's vividness of color and sharpness of shape.

Generally, these two aspects of a meditative state are understood to work somewhat at odds with each other in the case of novice meditators. That is, in the case of a novice, the greater the stability of the meditative state, the more likely is it to lack intensity. And the greater its intensity, the more likely is its lack of stability. This tension between stability and clarity is expressed in the two main flaws that hinder a meditation: "dullness" (Tib., *bying ba*) and "excitement" (Tib., *rgod pa*). When dullness first arises, the focus on the object will be retained, but as dullness progresses, the clarity of the object becomes progressively hindered, and a sensation of drowsiness overtakes the meditator. If dullness continues, the dimness of the object will cause the meditator to lose focus on it, or in the case of gross dullness, the meditator will simply fall asleep. In contrast, when excitement occurs, the clarity of the object will often increase, but the intensity of the mental state perturbs the meditation such that distractions easily arise and focus on the object is lost (Thrangu & Johnson, 2004; Tsongkhapa, 2002; Wangchug Dorjé, 1989).

In most practices, the ideal meditative state – one beyond the novice stage – is a state in which neither dullness nor excitement occurs; in short, stability and clarity are balanced perfectly. Hence, for the Tibetan contemplative traditions (and indeed, for nearly every other Buddhist tradition), it would be incorrect to interpret Buddhist meditation as "relaxation." This is not to deny the importance of mental and physical techniques that help the practitioner relax. Without such techniques, an excess of physical or mental tension may develop, and when such tension occurs, excitement will almost certainly arise. If, however, such relaxation techniques are overused, they are likely to propel the practitioner into dullness and hence hinder the meditation. Indeed, from a Buddhist perspective a practice that only relaxes the mind might eventually prove harmful. That is, such a practice would develop a great deal of dullness, and as a result the practitioner might become withdrawn, physically inactive, and mentally depressed. Overall, then, Buddhist meditations avoid an excess of relaxation, and it is for this reason that very few practices are done while lying down. It is also worth noting that, just as the tradition contains techniques to ease mental or physical tension, it also espouses methods to counteract an excess of relaxation or dullness (Thrangu & Johnson, 2004; Tsongkhapa, 2002; Wangchug Dorjé, 1989).

Although the balance of clarity and stability as described above forms an overall paradigm for Tibetan Buddhist practices, it is important to recognize the ways in which that paradigm is modified for each practice. For example, novices hoping to develop the meditative state of *Rigpa Chôgzhag* or "Open Presence" may be taught to emphasize one or another feature in order to make initial headway in the practice. In short, they are encouraged to err on the side of clarity, because it is more important to avoid dullness than excitement in the early stages of that practice (Thrangu & Johnson, 1984; Wangchug Dorjé, 1989).

The practice of Open Presence raises another issue: the applicability of this model to meditations that do not focus on an object. In objectless practice, the loss of focus on the object or its degree of phenomenal vividness obviously cannot be taken as criteria for the degree of stability or clarity. Instead, stability becomes a marker for the ease and frequency with which the meditator is perturbed out of the state the meditation is intended to induce, and clarity refers to the subjective intensity of that induced state. Thus, after a session of Open Presence, a meditator who reports that the meditation was unstable but very clear would mean that, although the intended state was interrupted repeatedly, the subjective experience of the state was especially intense when it occurred.

A final aspect of the basic theory of meditation concerns the distinction between the actual meditative state (Tib., *dngos gzhi*) and the post-meditative state (Tib., *rjes thob*). In brief, the states developed in meditation are usually thought to create a post-meditative effect. In some cases, some phenomenal aspect of the meditation persists in the post-meditative state. For example, after a meditation in which one cultivates the experience of phenomenal content as seeming dreamlike, one's perceptions in the post-meditative state are also said to have a dreamlike quality for at least some period after arising out of meditation. In other cases, the post-meditative state involves a trait change. Meditation on love and compassion, for example, is alleged to inhibit the occurrence of anger between meditative sessions. From the Buddhist theoretical perspective, such post-meditative changes are often at least as important as the states induced during the meditation itself, and success in a practice is often measured by the strength of the effects that occur after meditation (Dalai Lama XIV, 1995; Thrangu & Johnson, 1984; Tsongkhapa, 2002; Wangchug Dorjé, 1989).

CONTEMPORARY PRACTICE AND PROBLEMS OF TERMINOLOGY

In the laboratory setting neuroscientific researchers are likely to encounter Buddhists who engage in contemplative practices located in three overall traditions: the Vipassanā or Insight Meditation movement located within Theravāda Buddhism, the Zen tradition of Japan, and the Tibetan tradition. One might encounter practices from other Buddhist traditions, but the meditations of the aforementioned three traditions are by far the most widespread. They are also the most likely to be practiced by persons, such as Europeans and North Americans, who are not native to the cultures in which the practices have developed (Coleman, 2002). Of these three traditions, the style of meditation taught in the Vipassanā traditions is especially emblematic, because the basic meditative style of Vipassanā closely resembles some foundational practices in the Zen and Tibetan traditions.

The Vipassanā or Insight Meditation movement consists of several loosely allied institutions and individuals that teach a style of meditation rooted in the older contemplative traditions of Theravāda Buddhism in Myanmar, Thailand, and Śrī Laṅka. Although it draws on older traditions, the Vipassanā movement is "modern" in that it makes a somewhat simplified and regularized set of meditation instructions available to a wide population that is not limited to celibate monastics (Coleman, 2002). In its most typical form, the early stage of Vipassanā practice consists largely of a basic *śamatha* style of meditation focused on the sensation made by the breath as it flows in and out of the nostrils, although sometimes another aspect of the breath may be taken as the object of meditation (Gunaratana, 2002). In the early stages, the aim of the meditation is to keep the attention focused on the breath without distraction – that is, without the attention wandering to some other object, such as a sensation or a memory. For beginners (and even for advanced practitioners), the attention inevitably wanders, and the usual instruction is to recognize that the mind has wandered – for example, to see that it is now focused on the pain in one's knee, rather than on one's breath – and then to "drop" or "release" the distraction (the knee pain) and return to the breath. Part of the aim is not only to develop focused attention on the breath but also to develop two other faculties: a meta-awareness that recognizes when one's attention is no longer on the breath and an ability to redirect the attention without allowing the meta-awareness to become a new source of distraction, as when one berates oneself for allowing the mind to wander (Gunaratana, 2002; Kabat-Zinn, 2005).

Given the description thus far, practices very similar to Vipassanā meditation are also found among contemporary practitioners of Zen and Tibetan Buddhism. Indeed, it is possible that the Vipassanā approach to meditation on the breath has led Zen and Tibetan practitioners to employ a similar style of breath-meditation to a much greater extent than they have in the past. Certainly, it is clear that in contemporary Zen and Tibetan practice, focusing the attention on the breath (or sometimes another static object) is often used as a means to develop the basic level of concentration required for more advanced forms of meditation. In many cases, these more advanced meditations aim to enhance the type of meta-awareness that is cultivated during the Vipassanā style of practice, and because the traditions have different ways of understanding and enhancing that meta-awareness, all three kinds of traditions – Vipassanā, Zen, and Tibetan Buddhism – diverge in their practices from this point forward.

Although Vipassanā meditation may be especially representative of a widespread and foundational style of practice in contemporary Buddhism, any discussion of Vipassanā meditation must address a problem of terminology: the often confusing use of the terms "mindfulness" and "awareness." In the Mindfulness-Based Stress Reduction (MBSR) designed by Jon Kabat-Zinn (2005), for example, the term "mindfulness" is used primarily to refer not to the focusing aspect of mind, but rather to the meta-awareness that surveys that focus and its relation to the intended object. Likewise, in MBSR the term "awareness" sometimes seems to stand primarily for attention or the focusing aspect of mind. In contrast, popular works on Tibetan Buddhist meditation, such as the work of Thrangu (Thrangu & Johnson, 2004), use these same two terms, but their meaning is reversed: "mMindfulness" refers to attention or focus, whereas "awareness" refers to a faculty of mind that surveys the mental state at a meta-level.

The confusion in English terminology is in part due to some confusion in the proper usage of the Buddhist technical terms themselves. Strictly speaking, *smṛti* – literally, "memory" – is the focusing aspect of mind, and historically it is often translated as mindfulness when used in the context of meditation. An obvious case is the common technical term *smṛtyupasthāna* (in Pāli, *satipaṭṭhāna*), usually rendered as "foundation of mindfulness." The problem, however, is that even though *smṛti* should stand only for the focusing aspect of mind, in both popular and technical Buddhist literature on meditation it is not infrequently assimilated to the meta-awareness mentioned above. One reason for this is that in the Vipassanā tradition, meditations that initially emphasize *smṛti* as the focusing faculty are themselves used as a means to thoroughly develop meta-awareness *(samprajanya* or *prajñā)* at a later stage in the practice (Gunaratana, 2002). It is therefore not surprising that *smṛti* becomes closely associated with the meta-awareness, but this imprecise use of *smṛti* has contributed to the confusion concerning the English terms "mindfulness" and "awareness."

To restate the problem using the terms discussed earlier, we should note that such authors as Thrangu (Thrangu & Johnson, 2004) employ the term "mindfulness" to refer to the *śamatha* aspect of a meditative practice – that is, the stability of the meditation. And these authors then use "awareness" for the *vipaśyanā* aspect of the practice; that is, the meta-awareness that is especially associated with the clarity of the meditation. Turning then to its usage in, for example, MBSR, one finds that mindfulness refers primarily to the *vipaśyanā* aspect of the practice, not the *śamatha* aspect.

Although this problem is simply one of terminology, it can prove quite confusing in a laboratory setting. In the case of Open Presence practice, Tibetan meditators will usually deny that their practice is of mindfulness (i.e., *dran pa'i nyer gzhag*), whereas in fact, they mean to say that they are emphasizing the development of some meta-awareness in a way that has many parallels with the mindfulness practice of Vipassanā meditators or persons trained in MBSR. For the researcher, one solution to this problem is again to be attentive to the particularities of the practice in question while keeping track of the fact that we have yet to standardize the English lexicon of technical terms for the analysis of meditation.

Another problem of terminology comes with the use of the term *śamatha* itself, especially in its Tibetan context. Our discussion thus far has used the term *śamatha* in three basic meanings: (1) a particular state in which one can allegedly focus on an object for an unlimited period of time, (2) a style of practice aimed at attaining that state, and (3) the aspect of any meditative state that constitutes its maximal stability. Already, these three meanings can lead to considerable ambiguity, but the second meaning is particularly troublesome. One problem is simply that the expression "*śamatha* meditation" is not sufficiently clear. That is, when Buddhist theorists are being precise, they recognize that *śamatha* meditation should be rendered more properly as "meditation aimed at obtaining *śamatha*."

But even after this clarification, a problem remains: When one practices *śamatha* meditation, which kind of *śamatha* is one trying to obtain? In other words, is one attempting to cultivate the ability to concentrate on an object for an unlimited period? Or is one trying to cultivate some other kind of maximal stability? The main problem here is that, in the Tibetan context, the term *śamatha* is used to refer to stability in meditations that do not even have an object; hence, in those cases *śamatha* cannot relate to concentration on an object. To make the matter even more complicated, there are Tibetan practices in which *śamatha* is used in connection with both kinds of meditations (i.e., with an object and without an object). Finally, even when *śamatha* is related to practices with an object, the object in question may differ considerably; an example with neuroscientific import is the difference between focus on the breath and focus on a visualized object. Indeed, traditional scholars, such as Thrangu (Thrangu & Johnson, 2004, p. 21), with all these issues in mind, caution their students about the potential for confusion caused by the ambiguity of technical terms such as *śamatha*.

As with the case of mindfulness and awareness, the problems with the term "*śamatha*" should remind researchers that the particularities of a practice may be obscured by ambiguous terminology, whether in the source language or in English translation. As a practical matter, one may even wish to avoid the term *śamatha* as a description of a practice. This is not to say that the term should be abandoned: Clearly, for both historical and theoretical reasons, *śamatha* must remain in the lexicon on Buddhist meditation. But when seeking to specify exactly what a practitioner is doing during meditation, it may be more useful to use other Buddhist terms as labels for a particular practice – or perhaps researchers will develop new terms in dialogue with practitioners. Otherwise, if one is not careful, one may be misled into believing that a wide set of disparate practices are the same because, for one reason or another, they may all be called "*śamatha* meditation."

Three Meditative States in Tibetan Buddhism

We have mentioned repeatedly the importance of attending to the particularity of the contemplative tradition whose practices might become part of a research agenda, and with this in mind, we now discuss briefly three specific forms of meditation found in Tibetan Buddhism. Part of our aim is to set the ground for a discussion of these practices, because they have already been the subjects of some preliminary neuroscientific research, as is presented below.

All three styles of meditation come from a particular strand of contemplative practice in contemporary Tibetan Buddhism. In Tibetan, a term for this style of practice is C*hag-zôg (phyag rdzogs)*, a compound that refers to two traditions of meditation: the "Great Seal" or C*hag-chen (phyag chen*; Skt. *Mahāmudrā)* of the Kargyü *(bka' brgyud)* school and the "Great Perfection" or *Dzôg-chen* (Karma Chagmé, 2000) of the Nying-ma *(Rnying ma)* or "Ancient" school. Although historically and institutionally distinct, for the last 200 years the Great Seal and Great Perfection traditions have become allied so closely that it is now exceedingly rare to find a practitioner who employs the techniques of only one style in complete isolation from the techniques of the other style. This is not to say, however, that there are no important differences between these two traditions. They differ especially in the details of their most advanced practices, and they also propose slightly different techniques for the three meditations discussed below. Nevertheless, for the purposes of the brief descriptions below, they may be treated as constituting a single overall style of contemplative practice.

The three practices in question are *Tsé-cig Ting-ngé-dzin (rtse gcig ting nges 'dzin)* or Focused Attention, *Rig-pa Chôg-zhag (rig pa cog bzhag)* or Open Presence, *and Mîg-mé Nying-jé (dmigs med snying rje)* or Non-Referential Compassion. All meditators in the *Chag-zôg* style receive at least some instruction in all three of these practices, and all advanced meditators will be thoroughly familiar with them.

FOCUSED ATTENTION (*TSÉ-CIG TING-NGÉ-DZIN*)

The Tibetan term *Tsé-cig Ting-ngé-dzin* or "Focused Attention" refers to a mental state in which the mind is focused unwaveringly and clearly on a single object. This state, which literally translates as "one-pointed concentration," occurs in many practices, and it is a typical goal for novices in the *Chag-zôg* traditions. The relevant Buddhist theories and techniques are usually drawn from a generic account of practices that seek to develop *śamatha* in the sense of the ability to focus on an object for an unlimited time. This generic account, sometimes called "common *śamatha*" *(thun mong gi zhi gnas)*, differs from the present context. That is, in actual practice, *Chag-zôg* practitioners of Focused Attention usually develop a lesser (and often unspecified) state of concentration before being instructed by their teachers to move on to other practices, which no longer involve focusing on an object (Thrangu & Johnson, 2004). Nevertheless, the practice of cultivating Focused Attention draws heavily on the theories and techniques of common *śamatha*. Perhaps the most important principles drawn from that generic account can be summarized under six overall issues: the setting, the body posture, the object, the flaws that hinder progress, the "antidotes" to the flaws, and the stages of development in meditation (Tsongkhapa, 2002).

Although sometimes neglected in scholarly work on Buddhist meditation, the setting for meditation is clearly considered by traditional authors to be an important element in developing the ability to concentrate on an object (Thrangu & Johnson, 2004; Tsongkhapa, 2002; Wangchug Dorjé, 1989). One aspect of setting is the context formed by the other practices in which a meditator is engaged. These practices include especially formal guidance received from one's preceptor, the study of Buddhist thought, a wide range of devotional practices, and the observance of a basic moral code based upon non-harm *(ahiṃsā)* and compassion. Another aspect of setting concerns the site where one is to meditate. In this regard, traditional accounts speak at length about the need for a quiet place with few distractions and adequate access to food and water. So too, the spot to be used for meditation is prepared by the meditator on a daily basis by cleaning it and preparing it through various ritual activities.

Once preparations for the session are complete, the meditator adopts the posture for meditation. Various styles of Tibetan meditation involve different postures, but in the context of developing Focused Attention, the general rule is that the spine must be kept straight and that the rest of the body must be neither too tense nor too lax (Thrangu & Johnson, 1984; Tsongkhapa, 2002; Wangchug Dorjé, 1989). At this point, another element of the setting – the use of memorized formulas to induce the proper conceptual attitude – is invoked, and depending on the practice in question, a number of other practices or ritual activities may precede the portion of the practice in which one seeks to develop Focused Attention.

When actually engaged in the practice of Focused Attention, the meditator focuses the mind on the object to be meditated upon. This object may be a sensory object, such as a visible object in front of the meditator, or it might be mental, such as a visualized image (Thrangu & Johnson, 2004; Wangchug Dorjé, 1989). In general, Tibetan practitioners do not use the breath as an object of meditation, except perhaps for relatively brief periods as a means to settle the mind (Thrangu & Johnson, 2004). This trend may be changing, however, in part because of the modern encounter with other Buddhist traditions. To a great extent, the particular object chosen depends largely on the particular practice (such as tantric visualization or Open Presence) that forms the overall context for the development of Focused Attention.

Having placed the attention on the object, the meditator then seeks to avoid two overall flaws: dullness and excitement. As mentioned above, in the early stages, these flaws manifest in a straightforward fashion. Dullness is detected by, for example, a dimming or blurring of the object and, in its most gross form, a sensation of drowsiness. The main symptom of excitement is distraction (i.e., the intensity of the focus causes one to be hyperaroused, and as a result, attention wanders to other mental content or phenomena; Thrangu & Johnson, 1984; Tsongkhapa, 2002; Wangchug Dorjé, 1989).

In practice, the usual technique to counteract excitement is to become aware of the occurrence of the distracting content or phenomenon – that is, one notes the fact that the mind is now attending to another object, and then one returns the mind to the intended object without allowing the original distraction to produce more mental distractions, such as the thought, "It is not good to be distracted" (Thrangu & Johnson, 2004). Sometimes excitement is also caused by physical or environmental factors – too much tension in the body or too much bright light in the meditation area, for example. Or, excitement may be caused by applying too much effort to the meditation (i.e., being too rigid in one's focus). Similarly, in the case of visualized objects, excitement might be caused by too much intensity or brightness in the visualized object. Sometimes an affective remedy is used; for example, the meditator might temporarily switch to a contemplation of suffering, and the affective impact of that contemplation will reduce excitement enough that one can return to the original object of meditation. Various visualizations – such as visualizing a small black drop behind the navel – may also be employed to counteract excitement and allow the meditator to return to the original object of meditation (Wangchug Dorjé, 1989).

In terms of dullness, methods to counteract it are often related to those that counteract excitement. For example, just as one might counteract excitement by meditating in a dimly lit room, one can counteract dullness by meditating in a brightly lit setting. So too, adding tension to the body or intensity to a visualized object can also counteract dullness. And in terms of affective methods, the meditator might temporarily contemplate joy or compassion (and sometimes even fear) so as to energize the mind enough to return to the original object. As with excitement, visualizations may also be employed; for example, one may visualize a white dot on one's forehead at the point between the eyes (Wangchug Dorjé, 1989).

For advanced meditators, many of the "antidotes" mentioned here are too coarse, and they would lead to an overcorrection in the meditation. For these practitioners, the subtle degree of dullness or excitement that they encounter is corrected by equally subtle adjustments to the clarity (for dullness) or the stability (for excitement) of the meditation state until both stability and clarity reach their maximal, balanced state.

The notion that advanced meditators employ different responses to flaws in meditation raises the final relevant issue in traditional accounts; namely, the theories about the progression of stages in meditation. Many contemplative traditions speak of ascending stages through which the practitioner passes; a typical account speaks of nine levels of progressively higher degrees of concentration along with corresponding changes in the meditator's response to dullness and excitement (Thrangu & Johnson, 1984; Tsongkhapa, 2002; Wangchug Dorjé, 1989). This schema, however, is far more complicated than it seems, and as Apple (2003) demonstrates, the Buddhist penchant for scholasticism makes this topic an extremely complicated one when it is considered in its fullest form. Without going into great detail, it is important to note that, according to these schemas, a single practice may progress gradually through a number of meditative states, but some of those states might differ significantly from each other both phenomenally and in terms of the appropriate technique to be applied. Likewise, the mental and physical effects of a practice may build gradually; for example, as one's level of concentration improves, mental and physical well-being is also said to increase But some effects occur only at some stages and do not progress further (Tsongkhapa, 2002).

In terms of the most relevant effects that are traditionally expected to arise from this practice, the main result of Focused Attention is a greater ability to concentrate and a concomitant decrease in susceptibility to being perturbed out of a concentrated state. The practice is also thought to increase not only the stability of one's concentration but also its intensity. At the higher levels of practice, this type of meditation is also said to reduce the need for sleep, and during the meditation it is thought to induce pleasurable sensations, including a lightness or pliancy of mind and body.

OPEN PRESENCE (*RIG-PA CHÔG-ZHAG*)

Open presence or *Rig-pa Chôg-zhag* is one of the main meditative states that practitioners following the *Chag-zôg* style of practice attempt to cultivate. The basic motivation for the practice is rooted in a Buddhist axiom mentioned earlier: Namely, that one's negative emotional habits and behaviors arise from a set of mental flaws that cause one to consistently misconstrue both one's identity and also the objects toward which those emotions and behaviors are directed. As noted above, those flaws are meant to be corrected by *vipaśyanā* meditation through which one cultivates an accurate understanding of the nature of one's identity and the nature of objects in the world. In this sense, Open Presence may be considered a particular version of *vipaśyanā*. *Chag-zôg* theorists, however, have a unique understanding of what it means to gain the understanding or "wisdom" (Tib. *ye shes*) that counteracts flaws by seeing the true nature of identity and objects. And because the practice involves many discursive strategies that are based upon an underlying theory, one must have some sense of those theoretical underpinnings. Hence, even though our presentation aims to focus on empirical descriptions of what practitioners actually do, a brief foray into more abstract theory is necessary. Our theoretical discussion is based on three authors who are typical of the *Chag-zôg* traditions: Karma Chagmé (2000), Thrangu (Thrangu & Johnson, 2004), and Wangchug Dorjé (1989). Our concise and thematic presentation, however, might not be satisfactory to a strict traditionalist, in part because the issues involved are notoriously difficult to explain. Nevertheless, from an academic and anthropological standpoint, this presentation should suffice to convey the main theoretical issues relevant to this style of contemplation as it is practiced currently.

Theoretical Background. When justifying and explaining the types of practices that induce Open Presence, *Chag-zôg* theorists, such as Karma Chagmé (2000), Thrangu (Thrangu & Johnson, 2004), and Wangchug Dorjé (1989), argue that, properly speaking, objects are only known through experience; it is nonsensical to speak of objects separate from experience. Likewise, experience of an object necessarily involves a subject that experiences the object, and it is therefore nonsensical to speak of objects without speaking of a subject. The theoretical linchpin is that the nature of both objects and subjects is that which characterizes them under any circumstances – it must be essential to them, rather than accidental. And what is essential to them is that they always occur within experience. Hence, to know the nature of objects and subjects is to know the nature of experience (Thrangu & Johnson, 2004).

Whatever may be the philosophical merits of such an analysis, *Chag-zôg* practitioners are thus aiming to understand the nature of experience – that which is essential to any instance of experience, regardless of the accidental and changing features of the objects or subjectivities involved. To do so, they employ a set of techniques that are intended to make the practitioner aware of the invariable feature of all experiences. They speak of this invariable feature using various descriptions, including *Rigpa*, "Awareness," or, using the metaphor of light, *Selwa (gsal ba)*, "Luminosity" or "Clarity." But whether called Awareness, Clarity, or some other synonym, the point is that the invariant element in experience is that which, from a phenomenal standpoint, makes it possible for the subject-object relation to be presented in experience.

As the alleged invariant in all states of knowing, Awareness contrasts with features that are accidental (i.e., not essential) to any given cognition; namely, the particular features of the object and subject occurring within the cognition. What is accidental about the object are its characteristics, such as color or shape. And what is accidental about a subject is, for example, its temporal location in the narrative of personal identity or the particular emotional state that is occurring with the subjectivity. Hence, a meditative technique that enables the practitioner to know Awareness or Clarity must somehow avoid attending to the particularities of object and subject and grant access instead to the fact of knowing itself. The problem, according to *Chag-zôg* theorists, is that untrained persons are deeply entangled in the accidental features of experience; generally, they focus especially on the features of the object, and occasionally they are explicitly aware of themselves as subjects. But in either case, untrained persons are not aware of what is invariant in those experiences.

To overcome this problem, the various lineages of contemplative practice that fall under the rubric of *Chag-zôg* propose distinct techniques, but one common approach is based upon a move toward subjectivity in meditation. The notion here is that the invariant aspect of experience is closely tied to the reflexive awareness (Tib. *rang rig*) that enables one to have memories of oneself as an experiencing subject. On this theory, as an object is being presented to an experiencing subject, reflexive awareness also presents the process or occurrence of that experience either passively or involuntarily. For *Chag-zôg* theorists, this faculty of apperceptive presentation is a derivative form of the more fundamental Awareness that is the basic nature or structure of consciousness itself. Hence, a meditative technique that removes the cognitive features that usually obscure the implicit reflexivity of experience is one that moves that practitioner closer to an understanding of that fundamental Awareness.

Above we noted that even the earliest forms of *vipaśyanā* meditation seem to involve some form of meta-awareness that surveys the meditative state in such a way that it enables one to know whether one has lost the focus on the object. Likewise, that same type of meta-awareness serves to determine whether or not dullness and excitement are occurring. Thus, even in these other forms of *vipaśyanā* practice, one encounters a type of reflexivity, inasmuch as the meditative state is meant to involve an awareness of the state itself. With this in mind, one can think of the *Chag-zôg* practice of cultivating Open Presence as emphasizing this aspect of *vipaśyanā* practice to its furthest possible point. This practice differs from other meditations, however, in that theoretically it is taking an implicit aspect of all cognitions – a fundamental form of reflexivity – and making it phenomenally accessible to the practitioner.

On this theoretical understanding of Open Presence, two features of the practice are especially salient. First, in other meditations that fall under the general rubric of *vipaśyanā*, one cultivates a faculty of mind that is best described as a meta-awareness; it is "meta" in that it is dependent upon the mindfulness *(smṛti)* that is focusing the mind on the object at hand. As noted above, this meta-awareness surveys the mind itself so as to determine, for example, whether it is dull or excited. Thus, inasmuch as it focuses on cognition itself, the meta-awareness is reflexive, and to this degree it resembles the type of state cultivated in the practice of Open Presence. The difference, however, is that in Open Presence the prefix "meta" would be inappropriate; instead, it is assumed that, rather then being attendant upon the basic faculty of mindfulness – i.e., the faculty that focuses on an object – the reflexive aspect of mind is actually more fundamental than mindfulness. In other words, mindfulness must occur with an object, but the possibility of objects being presented in experience is itself rooted in a more fundamental reflexivity.

The second distinctive aspect of Open Presence is that, unlike other meditations, at advanced stages of the practice there is no attempt either to suppress or to cultivate any particular mental content. One does not focus, for example, on a visualized image or on a sensory object, such as a sensation made by the breath. In this sense the state of Open Presence is objectless. Nevertheless, even though higher levels of the practice do not involve any particular content or object, it also is important for content to be occurring in the mind because to cultivate an awareness of the invariant nature of experience, one must be having experiences. Indeed, for beginners it is preferable that the experiences be especially striking or clear. Thus, even though the meditation is objectless, it is not a state of blankness or withdrawal. Sensory events are still experienced, sometimes even more vividly. In terms of technique, this facet of the meditation is indicated by the fact that one meditates with the eyes open and directed somewhat upward.

Basic Practice. The actual state of Open Presence is one in which the meditator is aware of the Clarity or Awareness that makes all cognitions possible. This state is a relatively advanced one, and even experienced practitioners may not be able to sustain it for more than a short period of time. There are, however, a series of practices that train inexperienced meditators to cultivate Open Presence, and even experienced practitioners sometimes modulate their practice so as to move up or down the scale of practices, depending on how well the particular session is proceeding.

Schematically, we use the diagram in Figure 19.1 to summarize the stages of the style of practice that leads to Open Presence:

Stage	Object	Subject	Reflexive Awareness
1	+	−	−
2	−	+	+
3	−	−	+
4	Ø	Ø	++

Legend: "−" = de-emphasis, "+" = emphasis, "Ø" = absent

Figure 19.1.

This diagram is based especially on the styles of *Chag-zôg* practice exemplified by Karma Chagmé (2000), Thrangu (Thrangu & Johnson, 2004), and Wangchug Dorjé (1989),and their works are the main textual sources for the presentation below. It is important to note, however, that the diagram suggests a trajectory of actual practice that, although clearly implicit in these authors' writings, is not explicit. Nevertheless, this way of presenting the flow of the practice has the advantage of being far less complicated than traditional presentations.

As Figure 19.1 illustrates, in this style of practice the overall trajectory begins with a meditation that develops concentration on an object. One then employs techniques that cultivate an awareness of subjectivity in a manner that de-emphasizes the object. In doing so, one gains phenomenal access to the reflexive awareness that is thought to be invariant in cognition. One then de-emphasizes subjectivity as well so as to further enhance that access to reflexivity, and finally one practices so as to move to the point where the invariant aspect of awareness is realized fully in meditation. Throughout this entire process the close guidance of an instructor is considered essential.

This style of practice generally begins with the development of Focused Attention (i.e., concentration on a particular object as described previously). Initially retaining some focus on the object, one then cultivates

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attention to the state of the subjectivity observing the object. This is in part accomplished by discursive strategies that are implemented after a certain level of concentration and mental calm has been reached. In one such strategy, one is instructed to ask questions about the object, such as, "Is it inside the mind or outside the mind?" Or, when an appearance arises, one observes it and asks, "Where did it arise from?" Or as it abides in the mind, one asks, "Where is it abiding?" Or as it disappears, one asks, "Where did it go?" These questions and similar discursive strategies are used to train one to see the object as just a phenomenal appearance and to create the subjective impression that the appearance is not something separate from one's mind. As a means to heighten one's awareness of subjectivity, the same types of questions are then applied to the phenomenal appearance as mind (with questions such as, "What color is the mind?" "What shape is the mind?"), which has the effect of pointing out the manner in which the phenomenal content is accidental to the experience. Along with or in lieu of such strategies, a deliberate perturbation – such as a sudden shout – may be introduced into the meditation so that the effects on subjectivity will be especially salient.

The move to an emphasis on subjectivity is further encouraged by dropping any deliberate focus on an object. As a sensory content or mental event occurs, one observes it (sometimes along with the momentary use of a discursive strategy), and then one releases any focus on it. This is similar to the Vipassanā practice discussed above, except that after releasing the content or event one does not return to any object. Instead, one releases the mind into its "natural state" *(rang babs)*, which one understands to be the state reflecting only the invariant nature of consciousness and not the accidental properties of subject and object.

One is also repeatedly reminded by one's instructor that "grasping" *('dzin pa)* – taking the mental content as an object – is to be avoided. Here, the gross symptoms of grasping include indications that one has begun to focus on or examine the content or event and then elaborate upon it – in a phrasing often employed in oral instructions, one is not to "follow along" *(rjes su 'brang ba)* a chain of thoughts. A much subtler indication of grasping, however, is simply the fact that, in phenomenal terms, the appearance or event seems separate from the subjectivity in the experience. Thus, when one "releases" objects, one must do so with the understanding that the objects actually are not separate from awareness itself, of which the subjectivity is also just a facet. This attitude is initially developed through discursive strategies, which seem to play a crucial role in developing Open Presence.

Having become adept at emphasizing subjectivity –attending to the state of one's awareness without construing its contents as separate from the subjectivity – the next stage of the practice involves techniques that de-emphasize subjectivity itself. Theoretically, this is accomplished in part by one's facility at releasing objects. That is, because awareness is construed as subjectivity in relation to objects, the practice of releasing objects will also erode subjectivity. But another important aspect of this stage of practice is not to grasp onto subjectivity itself as an object. That is, as one is attempting to abide in a state that is aware and yet not focused on an object, one may still have a sense of subjectivity that is caught up in an identity that extends beyond the particular moment – as such, that sense of an identity is considered an accidental feature of the state because it changes over time.

One of the many remedies employed here is the repeated (and somewhat paradoxical) instruction not to make an effort to meditate. In other words, for the meditator a persistent way that the sense of "I" manifests would be in the form of a thought, such as, "I am meditating." Such a thought involves conceptual and linguistic structures that connect to a sense of "I" located in the past and the future. And because that way of locating subjectivity – essentially as a narrative agent – changes from one cognitive context to the next, it is a type of subjectivity that is thought to obscure the invariant feature of consciousness. According to most traditional accounts, it is extremely difficult to de-emphasize subjectivity to this degree. As a result, most beginner and mid-range meditators engaged in the cultivation of open presence are likely to be actually meditating at the level below this stage; that is, the stage at which subjectivity is still emphasized.

Through the above techniques – along with other methods that involve visualizations and breathing exercises – advanced meditators are thought to eventually induce a particular phenomenal experience: The experience's content does not appear as an object over against a subject, and the experience also does not involve a sense of subjectivity that is articulated by conceptual or linguistic structures, even if those structures are only implicit. It is worth reiterating, however, that in de-emphasizing both object and subject, the aim of the practice is not to become withdrawn from experiences, whether perceptual or mental. Instead, the aim is for experiences to continue to occur even though the state de-emphasizes the particularity of the object and subject. It is in this way that, according to C*hag-zôg* theorists, one will become aware of the invariant feature of all states of consciousness.

Finally, at the highest level of practice, what we have described as a de-emphasis of both object and subject moves, at least theoretically, to a point where no elements of objectivity or subjectivity – whether in the form of conceptual structures, categories of time and space, or some other feature – remain in the experience. At this point, the invariant feature of cognition is said to be realized fully by the meditator, and this is the full-blown state of Open Presence. It seems that because this state is extremely advanced in each generation of practitioners the C*hag-zôg* traditions recognize only a small number of practitioners as having truly reached this level of practice.

In terms of the effects of the practice, one ability developed through cultivating Open Presence is the stability of the state – that is, one is not easily perturbed out of the state. The difference, however, is that unlike in Focused Attention, in Open Presence the stability is not constituted by the fact that other phenomena do not pull one away from the object on which one focuses. Instead, stability consists of one's ability to continue to experience phenomena without objectifying them and, ideally, without having a sense of an agentive or narrative subjectivity. The state thus seems to cultivate a type of *ipseity* or bare awareness. After a session, for advanced meditators the objects of perception will phenomenally appear to be less fixed and more like appearances in a dream or a mirage for at least some period afterward. And as one advances further, the state between sessions begins to seem more like Open Presence itself. The relevant longer-term traits that are expected to arise from cultivating Open Presence include most prominently a facility to regulate one's emotions, such that one is disturbed less easily by emotional states. The mind is also said to be more sensitive and flexible, and the cultivation of other positive states and traits is therefore greatly facilitated. All three of our main traditional sources (Karma Chagmé, 2000; Thrangu & Johnson, 2004; Wangchug Dorjé, 1989) make it clear that these and other indications are thought to be observable in behavior, because it is through observing and interviewing students that the meditation master is able to guide them in this difficult practice.

NON-REFERENTIAL COMPASSION (*MÎG-MÉ NYING-JÉ*)

Unlike practices oriented toward generating Focused Awareness or Open Presence, the practice of Non-Referential Compassion aims to produce a specific emotional state; namely, an intense feeling of lovingkindness.[5] The state is necessarily other-centered, but it is non-referential *(dmigs med)* in that it does not have any specific object or focus *(dmigs pa)*, such as a specific person or group of persons. Thus, in effect this meditation has two aspects: the cultivation of compassion and the cultivation of objectless awareness (i.e., Open Presence). Hence, this practice may be considered a kind of variation on Open Presence, but it also differs somewhat from Open Presence. That is, except for the earliest stages of the practice, in Open Presence the meditator does not usually require any particular mental content or event as the context for the cultivation of Open Presence. But in the cultivation of Non-Referential Compassion, one does require a particular mental event – the emotion of compassion – that forms the context for the cultivation of the objectless awareness that is Open Presence.

The two aspects of Non-Referential Compassion – compassion and Open Presence – must occur together for the meditation to be successful (Wangchug Dorjé, 1989), but although precise descriptions of this practice are not readily available, it appears that for many practitioners this practice requires a sequence within the session. In some cases, a meditator may first cultivate Open Presence and then cultivate compassion while retaining the state of Open Presence to the greatest degree possible. After compassion has been evoked, the meditator may then emphasize Open Presence once again, because the techniques for cultivating compassion may have led the meditator to stray from an objectless state. In other cases, a meditator may begin by first evoking compassion, and then, while the mind is suffused with compassion, the meditator will cultivate Open Presence.

The sequentiality of the practice, which does not apply to the most advanced practitioners, stems largely from the methods that are initially used to evoke a compassionate mental state. These methods often combine multiple techniques, most especially a discursive strategy (usually the steps of a memorized argument), a set of visualizations, and sometimes a litany or other recitation. In all the Tibetan traditions, three such meditations are widely practiced: the "Sevenfold Causal Instructions" *(sems bskyed rgyu 'bras man ngag bdun)*, the "Equanimous Exchange of Self and Other" *(bdag bzhan mnyam brjes)*, and the practice of "Giving and Taking" *(gtong len)* (Dalai Lama XIV, 1991, 1995).

All three of these practices, which themselves may be combined in various ways, typically begin with an evocation of equanimity *(btang snyoms*, Skt, *upekṣā)*. Often a visualization of three persons is used: a beloved person (most especially one's mother), a person for whom one has some enmity, and a person toward whom one feels indifference. With a visualization of these persons in place, one then employs discursive strategies – such as the argument that all beings are equal in wanting to be happy and wishing to avoid suffering – that are designed to eliminate one's biases toward these persons. In the Sevenfold Causal Instructions, one is then encouraged not only to see all beings as equal but also to take one's mother as paradigmatic of all beings. Another set of discursive contemplations – sometimes including specific visualizations – are then used to displace one's preferential treatment of oneself over others. One contemplates, for example, how despicable one would be to prefer one's own happiness over the well-being of one's mother; here, the practitioner might recall a memorized aphorism or the admonitions of his or her teacher. Finally, by recalling or visualizing the intense suffering experienced by others – i.e., "all sentient beings who are as if one's mother" *(ma sems can thams cad)* – one becomes motivated empathetically to eliminate that suffering. Toward the endpoint of this process one experiences a visceral, emotional reaction that is said to involve especially a feeling of opening at the center of the chest, sometimes accompanied by horripilation and the welling of tears in the eyes. This state involves both love *(matrī)* – the aspiration that other beings be happy – and compassion *(karuṇā)* – the aspiration that other beings be free of suffering. At this point the state might involve a degree of sentimentality, and the final phase of developing compassion is meant to go beyond that state to one that is both more stable and also more engaged with aiding others (Dalai Lama XIV, 1991).

Most Tibetan practitioners are trained intensively in this type of contemplation for generating compassion. It is evident, however, that these techniques for inducing compassion are not objectless, inasmuch as they involve visualizations, arguments, aphorisms, litanies, and so on that are focused on objects of one kind or another. Nevertheless, having generated compassion, the practitioner can then cultivate Open Presence from within that state. Indeed, as a phenomenally intense state, compassion is well suited to the early stages of cultivating Open Presence, because compassion's intensity lends itself well to an awareness of subjectivity and, hence, reflexivity. And if the emotional state of compassion can be sustained even while one is cultivating Open Presence, the meditator is in the state of Non-Referential Compassion. As a meditator becomes more adept at cultivating compassion through the various techniques mentioned above, the mind becomes more habituated to the state such that an advanced practitioner can induce the state of compassion almost effortlessly. At this stage the practice would no longer require a sequence; that is, compassion can be cultivated directly within a state of Open Presence itself (Wangchug Dorjé, 1989).

In general the cultivation of compassion is thought to grant the meditator numerous beneficial effects between sessions, such as creating a general sense of well-being and aiding in counteracting anger or irritation. Long-term practitioners of this practice are also said to have an effect on others around them, in that other persons nearby may also feel a greater sense of well-being and happiness. Compassion is also thought to provide benefits when one is in a meditative session involving other practices. It is especially useful for counteracting torpor in meditation; that is, it is a considered a strong antidote for dullness, as mentioned earlier. Likewise, because compassion is other-centered, it is considered to develop traits that are essential for the successful cultivation of Open Presence. That is, in developing Open Presence one must eliminate the mind's "grasping" directed toward objects and also toward subjectivity itself. Grasping, moreover, is rooted in a persistent trait within the mind that absolutizes the standpoint of the subject. By persistently orienting the meditator toward others, compassion lessens this fixation on self and makes it possible for grasping to be eliminated through the practice of Open Presence. In this way, the cultivation of compassion is thought to train the mind in a way that is essential to the success of some practices (Dalai Lama XIV, 1991, 1995; Karma Chagmé, 2000; Thrangu & Johnson, 2004; Wangchug Dorjé, 1989).

Generating a Description

As the discussion above indicates, even within Buddhism a large number of distinct contemplative practices continue to be practiced in living traditions. For this reason, significant changes in meditative style are found even for a basic *śamatha* style of meditation focused on the sensation made by the breath. For instance, practitioners from the Vipassanā or Insight Meditation movement may practice this meditation with the eyes closed so as to de-emphasize the importance of the visual modality. In contrast, closing the eyes is rarely encouraged in the Zen and Tibetan traditions, in part because it is assumed to induce dullness or drowsiness.

The difference of opinion concerning the closing of the eyes is illustrative of the difficulties that researchers face when specifying the exact nature of a meditation to be studied. One main problem is that the traditional accounts of these practices move far beyond the sketches given here; instead, those accounts are usually highly detailed and extremely complex. Likewise, the terminology used to describe the practices is sometimes unreliable, either because of ambiguities in the traditions themselves or problems in translation. Practices from different traditions may in fact overlap significantly – the overlap between contemporary Mindfulness practice and Open Presence meditation is one case in point. Finally, subjects from traditionally Buddhist cultures sometimes are reluctant to depart from textual descriptions of meditative practices. To do so would require a practitioner to assert some authoritative experience as a meditator, and it is usually thought to be inappropriate to claim that degree of accomplishment in meditation.

Researchers may also encounter problems when attempting to assess the degree of training and practice over the life of a particular practitioner. One of the main difficulties is that, traditionally, contemplative practice involves many varieties of meditation, each of which mutually influence each other and differentially affect the mind. The quantification of the total hours of meditation throughout a practitioner's life is thus not straightforward and will require further methodological development.

In any case, before tackling the problem of quantification, an important task for any researcher is generating a precise and concrete account of the practices in which meditating subjects claim to be engaged. The best way to proceed is probably to develop a list of questions that can be used to help prompt descriptions from practitioners without getting caught either in traditional categories or issues of cultural translation. To assist researchers in this task, we close this section on Buddhist meditation with a practical series of sample questions that would aid both the meditator and researcher in defining more clearly the relevant facets of the practice to be studied. The questions address five overall issues: (1) the relative degree of stability and clarity appropriate to the practice; (2) the "intentional modality" (i.e., whether the meditation has an object); (3) the techniques, such as breath manipulation, that are employed; (4) the expected effects of the practice during meditation; and (5) the expected effects after a session. Although based especially on the practice and theory of meditation found in Tibetan Buddhism, questions of this type are likely to be useful when examining other contemplative traditions.

1. *Concerning stability and clarity, one may ask the following*:
   - In view of the practitioner's level, should the meditation favor stability, clarity, or a balance?
     - What are the indications that stability needs adjustment?
     - What are the indications that clarity needs adjustment?
2. *Concerning intentional modality, one may ask the following*:
   - If the meditation includes an object, then,
     - Is there one object or many objects in the meditation?
     - For each object, is the object dynamic or static?
     - If the object includes or consists of a visual form, a sound, or a sensation, then is the object perceived through the senses, or is it imagined in the mind through visualization or another technique?
   - If the meditation does not include an object, then does one direct one's attention to something else?
3. *Concerning meditative techniques, one may ask the following*:
   - Is the practice done with the eyes opened or closed?
   - Does the practice employ any discursive strategies, such as recitations, memorized descriptions, or arguments that one reviews?
   - Does the practice use breath manipulation?
   - Does the meditation involve focusing on different parts of the body by means of a visualization or some other technique?
   - Does the practice require a specific posture or set of physical exercises?
4. *Concerning expected effects during meditation, one may ask the following*:
   - Is the meditation expected to produce any physical sensations or mental events, either constantly or intermittently?
   - Does one expect the meditation to produce subjectively noticeable alterations in cognition, either constantly or intermittently? One example would be the impression that one's perceptions seem to be like the appearances in a dream.
   - Is the meditation expected to cause any emotions, either constantly or intermittently?
5. *Concerning expected effects after meditation, one may ask the following*:
   - Does one expect the meditation to alter one's cognitions? One example would be the impression that one's perceptions are more vivid.
   - Does one expect the meditation to alter one's behavior? One example would be a tendency to sleep less.
   - Does one expect the meditation to alter one's emotions? One example would be the tendency to recover more quickly from emotional disturbances.

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By adapting or adding to this list of questions for the particular practice in question, meditators and researchers may be able to collaborate more readily so as to describe in a straightforward way the major features of a practice that are relevant to a particular neuroscientific research agenda. With such descriptions in place, the dialogue between meditators and researchers can be far more precise, and the interaction between neuroscience and meditation is therefore likely to be more fruitful.

The Intersection of Neuroscience and Meditation

This section briefly explores some possible scientific motivations for the neuroscientific examination of meditative practices and their possible impact on the brain and body in advanced practitioners. The aim here is to clarify further the distinguishing features of this approach compared to other empirical strategies described in this handbook. Before we move forward with this discussion, however, two points of clarification need to be made. First, because of the relative paucity of currently available empirical data in this field, this section remains largely programmatic. Second, we discuss some studies that involve novice meditators, but the set of issues examined here are most relevant to advanced practitioners of meditation. Nevertheless, emphasis on advanced practitioners should not minimize the importance of studying meditation in less practiced individuals. Indeed, some of us have already done so (see, e.g. Davidson et al., 2003). For progress in this general area to advance, we believe that research on practitioners at all levels should be encouraged, but one must also recognize that the goals of studying individuals at different levels of accomplishment differ somewhat.

Turning now to the question of advanced practitioners, we begin by noting three frequently advanced hypotheses:

1. Advanced practitioners can generate *new data* that would not exist without sustained mental training. These data encompass either *meditative states* or *traits* induced by meditation. Meditative states refer to the transient alterations of experience voluntarily cultivated by a given meditation practice (i.e., bodily awareness, relaxation, emotions, and so on). Traits refer to the lasting changes in these dimensions that persist in the practitioner's daily experience irrespective of being actively engaged in meditation.
2. Advanced practitioners can robustly *reproduce* specific features in experience as cultivated in given meditative practice. This reproducibility makes those features scientifically tractable.
3. Advanced practitioners provide more *refined first-person descriptions* of their experiences than naïve subjects. Thus, the neurophysiological counterpart of these first-person accounts can be defined, identified, and interpreted more easily by the experimentalist.

We now discuss these claims in relation to three neuroscientific agendas: neuroplasticity, the interaction of mind and body, and the possibility of neural counterparts to subjective experience. In the course of this discussion, specific techniques from the Buddhist tradition serve as illustrations.

Transforming the Mind and Brain Neuroplasticity

From a neuroscientific perspective, the first promising claim made by Buddhist contemplative traditions is that experience is not a rigid, predetermined, and circumscribed entity, but rather a flexible and transformable process. On this view, emotions, attention, and introspection are ongoing and labile processes that need to be understood and studied as skills that can be trained, similar to other human skills like music, mathematics, or sports. This principle is foundational for Buddhist contemplative practice, because such practices are based upon the notion that the mind is malleable in this way. As a result, the methods employed by Buddhist contemplative practices resonate with widely accepted developmental models of basic cognitive processes; according to these models, cognitive functions are skills that critically depend upon learning from environmental input (e.g., McClelland & Rogers, 2003; Saffran, Aslin, & Newport, 1996). This basic stance reflects another well-accepted and well-documented theory; namely, that experience changes the brain. Interest in this feature, known as neuroplasticity, has prompted an explosion of research over the past decade.

As a result of ongoing research on neuroplasticity, we now have a detailed understanding of many of the molecular and system-level changes that are produced by specific types of experiential input. For example, neonatal rodents exposed to varying levels of maternal licking and grooming develop very different behavioral phenotypes. Those animals that receive high levels of licking and grooming (the rodent equivalent of highly nurturing parenting) develop into more adaptable and relaxed adults. Of great interest is the fact that the brains of the animals are critically affected by this differential rearing. Indeed, gene expression for the gene that codes for the glucocorticoid receptor is actually changed by this experience, and the detailed molecular pathways by which experience can alter gene expression have now been worked out in this model (Meaney, 2001). This program of research illustrates the profound ways in which neuroplasticity can unfold, and it demonstrates that experience-induced alterations in the brain can occur all the way down to the level of gene expression.

Meaney's work on alterations in brain gene expression implies that similar experience-induced alterations might occur in humans. Currently, however, there are no direct measures of localized neuronal gene expression that can be non-invasively obtained in humans. Nevertheless, other research suggests that such changes do indeed occur. For instance, the brain of an expert, such as a chess player, a taxi driver, or a musician, is functionally and structurally different from that of a non-expert. London taxi cab drivers have larger hippocampi than matched controls, and the amount of time the individual has worked as a cab driver predicted the size of the posterior hippocampus (Maguire et al., 2000). Further work by this group suggests that these differences in hippocampal size are the results of experience and training as a cab driver and not a consequence of pre-existing differences in hippocampal structure (Maguire et al., 2003).

Whether similar structural alterations in different regions of the brain occur also as a consequence of affective – rather than sensorimotor – experience is not definitively known, but all of the extant work at both the animal and human levels indicates that it does. Certainly there are good animal data to suggest that such changes occur, as indicated by the study on neonatal rodents. In humans, a variety of research indicates that deleterious conditions, such as chronic stress, neglect, and abuse, produce functional changes in the brain that are likely subserved by structural alterations (Glaser, 2000). Likewise, research on depression indicates that patients with mood disorders exhibit structural differences in several brain regions, including the hippocampus and territories with the prefrontal cortex; significantly, at least some of these differences are associated strongly with the cumulative number of days of depression in the patients' lifetimes (Sheline, 2003).

These findings raise the possibility that training and practices that are specifically designed to cultivate positive qualities, such as equanimity and lovingkindness, will produce beneficial alterations in brain function and structure. Presumably, these alterations would be most prominent in long-term, advanced practioners, but we have already shown that even very brief short-term training (30 minutes) in emotion regulation can produce reliable alterations in brain function (Urry et al., 2003). So too, we have observed that a 2-month course in Mindfulness-Based Stress Reduction (MBSR) can produce alterations in patterns of prefrontal brain activity that we have previously found to accompany positive affect (Davidson et al., 2003).

The findings concerning MBSR may be especially relevant, because MBSR is likely to provide a large pool of persons for the study of neuroplasticity and meditation. An 8-week program that was originally developed in a hospital setting for patients with chronic illnesses, MBSR is now applied across an extremely wide range of populations (Kabat-Zinn & Chapman-Waldrop, 1988; Kabat-Zinn, Lipworth, & Burney, 1985). The method, based primarily on Buddhist practices, seems to be effective for chronic pain, anxiety disorders, general psychological well-being, psoriasis, and recurrent depression (Grossman, Niemann, Schmidt, & Walach, 2004). The program seems to work by helping the patient distinguish primary sensory experience (e.g., chronic pain, physical symptoms of anxiety) from the secondary emotional or cognitive processes created in reaction to the primary experience. Individuals are trained to use the mindfulness practice to elicit the details of their experience and to directly perceive the unstable and contingent nature of the feelings and sensations that are associated with aversion and withdrawal; as a result, indviduals are better able to counter any propensity toward withdrawal and aversion in response to physical or psychological pain.

From a neuroscientific perspective, the apparent effectiveness of MBSR practice raises the question of neuroplasticity – that, is, does it produce alterations in brain function and structure? Recent data indicate a possible relationship between meditation training and changes in brain structure (Lazar et al., 2005). In this study, cortical thickness was assessed using magnetic resonance imaging. Increased cortical thickness could be caused by greater arborization per neuron, increased glial volume, or increased regional vasculature, all of which are important for neural function. Cortical brain regions associated with attention, interoceptive, and sensory processing were found to be thicker for a group of mid-range practitioners than for matched controls (the meditator participants had, on average, 40 minutes of daily practice of Insight meditation for an average of 9 years). We anticipate that research conducted over the next 2 years by several groups will further examine possible anatomical changes induced by meditation.

Mechanisms of Mind-Body Interaction

In addition to the study of neuroplasticity, one of the most potentially fruitful questions in the study of meditation is the impact of training the mind on peripheral biological processes that are important for physical health and illness. Quite literally, the question here is whether mental training can affect the body in a way that will have a significant impact on physical health. Although there are many popular claims about the health benefits of meditation and contemplative practice, there is relatively little that is solidly known about this potentially crucial issue. Even more importantly, there are preciously few attempts to mechanistically link the changes that are occurring in the brain with alterations that may be produced in peripheral biology. It is beyond the scope of this chapter to review the basic research relevant to these questions, but it provides some general guidelines and examples.

It is established that there is bidirectional communication between the brain and the periphery and that this communication proceeds along three basic routes: the autonomic nervous system, the endocrine system, and the immune system. In each of these systems, specific pathways and signaling molecules enable this bidirectional communication to occur. These structural characteristics are highly relevant to the possibility that meditation may influence physical health. That is, some conditions of peripheral biology may be potentially affected by meditative practices because those conditions – such as an illness – are susceptible to modulation by the autonomic, endocrine, and/or immune pathways involved in brain-periphery communication. Thus, because there is bidirectional communication between the brain and periphery, it is theoretically possible to affect those types of conditions by inducing changes in the brain through meditation. At the same time, however, other conditions or illnesses may not be influenced in this way by

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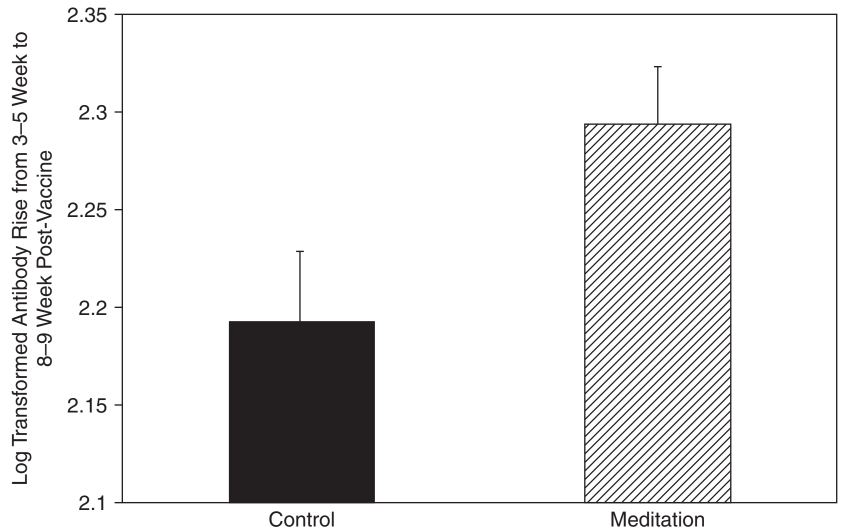

Figure 19.2. Effect of meditation training on the immune system during a Mindfulness-Based Stress Reduction program (8-week program) with novice practitioners. Means ± SE antibody increase from the 3- to 5-week to the 8- to 9-week blood draw in the Meditation and Control groups. The ordinate displays the difference in the log-transformed antibody rise between the 3- to 5-week and the 8- to 9-week blood draws derived from the hemagglutination inhibition array. (From Davidson et al., 2003.)

meditation because the peripheral biological processes in question cannot be affected by any pathway involved with brain-periphery communication.

With this in mind, the strategy that we have adopted in some of our work is to examine a proxy measure that we know can be modulated by central nervous changes and that is health-relevant. In a seminal study, Kiecolt-Glaser, Glaser, Gravenstein, Malarkey, and Sheridan (1996) reported that caregivers of dementia patients had an impaired response to influenza vaccine compared with a matched control group. Several groups have now independently replicated this basic finding and have examined some of the details regarding the mechanism by which stress might impair humoral immunity (e.g., Miller et al., 2004).

In our group, we have investigated whether individual differences in patterns of prefrontal brain activity that we have previously found to be associated with affective style (i.e., individual differences in profiles of affective reactivity and regulation) are also associated with differences in antibody response to the influenza vaccine. We found that individuals with high levels of left prefrontal activation, a pattern that we have previously found to predict more positive dispositional mood, had higher levels of antibody titers in response to the vaccine (Rosenkranz et al., 2003). The specific question of whether mental training could improve the immune response was addressed in our study of MBSR (Davidson et al., 2003; Figure 19.2). In this study, individuals who had been randomly assigned to an MBSR group were compared to a wait-list control group. Subjects were tested just after the MBSR group had completed their 8-week training. We found that the meditators exhibited a significantly greater antibody response to the influenza vaccine. Of most importance in this study was an analysis we conducted that examined relations between brain and immune function changes with meditation. We found that for the individuals assigned to the meditation group, those who showed the greatest shift toward left-sided activation also exhibited the largest increase in antibody titers to the

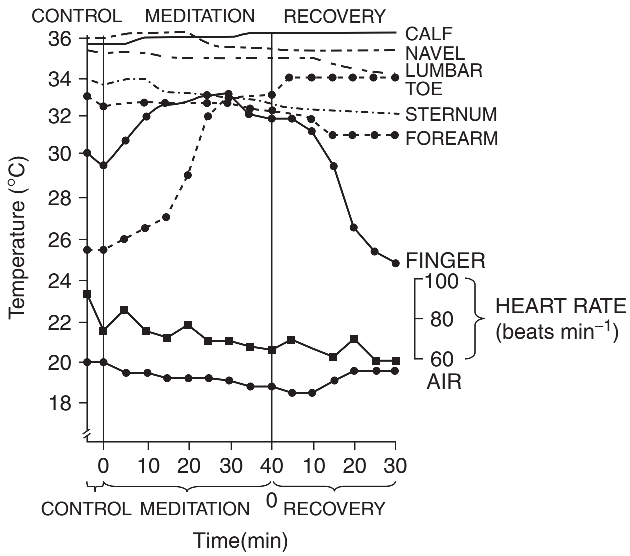

Figure 19.3. Effect of Tummo meditation of the regulation of body temperature. Skin and air temperature and heart rate changes before, during, and after the meditation of long-term practitioner L.T. (adapted from Benson et al., 1982).

vaccine. These findings suggest some association between the magnitude of neural and immune changes.

A variety of other findings in the literature suggest that autonomic changes occur during specific types of meditation. As noted in the first part of this chapter, the Tibetan Tummo practice has as its byproduct the production of heat. Benson and his colleagues reported on three practitioners and found that, by using this practice, they were indeed able to voluntarily increase temperature in their toes and fingers by as much as 8°C (Figure 19.3; Benson et al., 1982). Takahashi et al. in a study of Zen meditation in a fairly large sample ($N = 20$) found changes in heart rate variability (reflecting parasympathetic nervous system activity) that were associated with changes in specific EEG frequencies (Takahashi et al., 2005). In future studies, the combination of both brain and peripheral measures will be important in helping understand the mechanisms by which such peripheral changes may be occurring. This type of data will be especially useful as research moves forward on the practical question of whether meditative practices can affect the body in a way that improves health.

Using First-Person Expertise to Identify the Neural Counterpart of Subjective Experience

As discussed in the first section of this chapter, various meditative practices induce a wide variety of altered states of consciousness. It is thus frequently claimed that the study of meditation will contribute to our general understanding of the neural basis of consciousness. Here we aim to move beyond this general claim and illustrate how specific Buddhist practices might provide research opportunities to glean new insights about some of the brain mechanisms contributing to consciousness. More precisely, we discuss how the collaboration with long-term Buddhist practitioners is of great interest in the study of (1) the physical substrate of subjectivity or the self, (2) the physical principles underlying the emergence of coherent conscious states from unconscious brain processes, and (3) the functional role of the spontaneous brain baseline.

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STUDYING THE SUBSTRATE OF SUBJECTIVITY

One of the useful points of intersection between Buddhist contemplative practice and the neuroscience of consciousness is the emphasis on understanding the nature of the self. A comparison between Buddhist and neuroscientific models of the self is beyond the scope of this chapter, but it is important to note that both traditions distinguish between a minimal subjective sense of "I-ness" in experience, or ipseity, and a narrative or autobiographical self. Ipseity is the minimal subjective sense of I-ness in experience, and as such, it is constitutive of a minimal or core self. By contrast, a narrative or autobiographical self (Legrand, 2005) encompasses categorical or moral judgment, emotions, anticipation of the future, and recollections of the past. This explicit sense of narrative or autobiographical self is often characterized as occurring in correlation with an explicit content, or object, of experience. It also appears to be dependent in some fashion on ipseity, inasmuch as the narrative self is in part based upon that minimal subjective sense of I-ness.

The notion of ipseity is further explained through Western phenomenological theory, according to which one can speak of experience in terms of both transitive and intransitive modes of consciousness. Any experience "intends" (i.e., refers to) its intentional object; this is its transitive aspect. At the same time, the experience is also reflexively manifest to itself, and this is its intransitive aspect. On this theory, the intransitive aspect of experience is a form of self-consciousness that is primitive inasmuch as it (1) does not require any subsequent act of reflection or introspection, but occurs simultaneously with awareness of the object; (2) does not consist of forming a belief or making a judgment; and (3) is passive in the sense of being spontaneous and involuntary (Zahavi & Parnas, 1998). For instance, when one consciously sees an object, one is also at the same time aware of one's seeing; similarly, when one visualizes a mental image, one is also aware of one's visualizing. This tacit self-awareness has often been explained as involving a reflexive awareness of one's lived body or embodied subjectivity correlative to the experience of the object (Mearleau-Ponty, 1962; Wider, 1997). It is, in short, another way of speaking about ipseity.

If the above model is correct, then in giving an account of consciousness, neuroscience needs to explain both "how the brain engenders the mental patterns we experience as the images of an object" and "how, in parallel . . . the brain also creates a sense of self in the act of knowing . . . " In other words, to give an account of consciousness, neuroscience must show how it is that one has a "sense of me" by demonstrating "how we sense that the images in our minds are shaped in our particular perspective and belong to our individual organism" (Damasio, 1999, pp. 136–137). As a number of cognitive scientists have emphasized, this primitive self-consciousness might be fundamentally linked to bodily processes of life regulation (Damasio, 1999; Panksepp, 1988).

This approach to the question of consciousness suggests a research strategy that might be aided by the use of experienced meditators. That is, to understand consciousness, it is presumably best to begin by examining it in its simplest form. And on this theory, the simplest form of a conscious state is reducible to ipseity, which is required for or is prior to the narrative self. One experimental strategy would be to involve long-term practitioners of a practice such as Open Presence that allegedly induces a state in which ipseity is emphasized and the narrative self is lessened or eliminated. By examining such practices, one may be able to find neural correlates of a bare subjectivity, which in turn may yield some insight into the neural correlates of the most basic type of coherent states that we call consciousness.

STUDYING THE SUBSTRATE OF CONSCIOUSNESS

Empirical evidence clearly indicates that only a selective set of neurons in the brain participates in any given moment of consciousness. In fact many emotional, motor, perceptual, and semantic processes occur unconsciously. These unconscious processes are usually circumscribed brain activities in local and specialized brain areas (Dehaene & Naccache, 2001). This result suggests that, when a stimulus is phenomenally reportable from the standpoint of experience, it is the result of translocal, large-scale mechanisms that somehow integrate local functions and processes. In other words, it has been hypothesized that the neural activity crucial for consciousness most probably involves the transient and continual orchestration of scattered mosaics of functionally specialized brain regions, rather than any single, highly localized brain process or structure (Dehaene & Naccache, 2001; Llinas, Ribary, Contreras, & Pedroarena, 1998; W. Singer, 2001; Tononi & Edelman, 1998).

The issue at stake here can be illustrated by the example of binocular rivalry. When the right eye and the left eye are presented with competing, dissimilar images, the observer does not experience a stable superimposed percept of the images presented to the two eyes, but instead perceives an ongoing alternation between the images seen by each eye every couple of seconds. When one percept is consciously perceived, the other remains unconscious. Yet, even if a stimulus is not reportable, there is evidence it is still processed by the brain in various ways. Activity in the amygdala, which is known to increase during the presentation of facial expressions of fear and anger, is still detectable even when the emotional face is suppressed because of binocular rivalry (Williams, Morris, McGlone, Abbott, & Mattingley, 2004).

Binocular rivalry suggests that local neural processes – such as those involved in the processing of visual stimuli – are not in themselves sufficient to account for consciousness. In other words, the neural process occurs, but may or may not be consciously experienced. Some other process or mechanism must be involved. It is in response to this type of issue that contemporary researchers (Llinas et al., 1998; Singer, 2001; Tononi & Edelman, 1998) have hypothesized some kind of integrative mechanisms or processes that, although transient, are able to orchestrate or coordinate functionally specialized brain regions. A common theoretical proposal is that each moment of conscious awareness involves the transient selection of a distributed neural population that is both integrated or coherent, and differentiated or flexible, and whose members are connected by reciprocal and transient dynamic links. As we show in the next section, neural synchronization and de-synchronization between oscillating neural populations at multiple frequency bands are popular indicators of this large-scale integration (Engel, Fries, & Singer, 2001; Varela, et al. 2001). For instance, during the binocular rivalry discussed above the alternation of perceptual dominance correlates with different ongoing patterns of distributed synchronous brain patterns (Cosmelli et al., 2004; Srinivasan, Russell, Edelman, & Tononi, 1999).

Thus it is hypothesized that large-scale integrative mechanisms play a role in conscious processes. However, these large-scale brain processes typically display endogenous, self-organizing behaviors that cannot be controlled fully by the experimenter and are highly variable both from trial to trial and across subjects. Linking these brain patterns to the experiential domain is notoriously difficult in part because the first-person reports are readily inaccurate or biased (Nisbett & Wilson, 1977). The problem, in a nutshell, is that the experimenter is led to treat as noise the vast majority of the large-scale brain activity, as he or she can neither interpret it nor control it.

It is in this context that meditation becomes relevant. We hypothesize that long-term practitioners of meditation can generate more stable and reproducible mental states than untrained subjects and that they can also describe these states more accurately than naïve subjects. The practitioners' introspective skills could provide a way for experimenters to better control, identify, and interpret the large-scale integrative processes in relation to the subjective experience.

This "neurophenomenology" approach (Varela, 1996) was tested in the context of a visual protocol with naïve subjects. On the day of the experiment, participants were first trained during a practice session to be aware of subtle fluctuations from trial to trial in their cognitive context as defined by their attentive state, spontaneous state processes, and the strategy used to carry out the task. During the visual task, their electrical brain activity and their own report about their cognitive context were recorded. Trials were clustered according to the acquired first-person data, and separate, dynamical analyses were conducted for each cluster. Characteristic patterns of synchrony in the frontal electrodes were found for each cluster, depending in particular on the stability of attention and the preparation to do the task (Lutz, Lachaux, Martinerie, & Varela, 2002).

As discussed in the report by Lutz and Thompson (2003), the collaboration with long-term practitioners will be particularly relevant to the further extension of this research strategy. Let us return again to the binocular rivalry paradigm. The perceptual selection in rivalry is not completely under the control of attention, but can be modulated by selective attention (Ooi & He, 1999). Evidence suggests in particular that the frequencies of the perceptual switch can be controlled voluntarily (Lack, 1978). It is possible that long-term practitioners of Focused Attention meditation can gain a more thorough control of the dynamic of perceptual switch than naïve subjects and that they can also refine their descriptions of the spontaneous flow of perceptual dominance beyond the mere categories of being conscious of one or another percept, thereby leading possibly to new brain correlates. Carter et al. (2005) recently provided behavioral evidence that long-term practitioners can indeed change the rivalry rate during meditation. They reported differential effects on visual switching accompanying rivalry during Non-Referential Compassion meditation and Focused Attention meditation (see the earlier discussion on meditative states in Tibetan Buddhism) among 23 Tibetan Buddhist monks varying in experience from 5 to 54 years of training. Compassion meditation led to no modification in rivalry rate, in contrast with Focused Attention meditation, which led to extreme increases in perceptual dominance durations that were reported by 50% of monks after a period of single-pointed meditation. The monks reported additional stabilization of the visual switching when they did the visual task during Focused Attention meditation.

In sum, the capacity of long-term practitioners to examine, modulate, and report their experience might provide a valuable heuristic to study large-scale synchronous brain activity underlying conscious activity in the brain.

Meditation and Physiological Baselines

A central goal of the practice of meditation is to transform the baseline state of experience and to obliterate the distinction between the meditative state and the post-meditative state. The practice of Open Presence, for instance, cultivates increased awareness of a more subtle baseline (i.e., ipseity) during which the sense of an autobiographical or narrative self is de-emphasized. Long-term training in Compassion meditation is said to weaken egocentric traits and change the emotional baseline. Practitioners of Mindfulness/Awareness meditation aim to experience the present nowness, and this type of meditation affects the "attentional baseline" by lessening distractions or daydream-like thoughts. In this way, meditative practices are generally designed to cultivate specific qualities or features of experience that endure through time relatively independent of ongoing changes in somatosensory or external events. These qualities are thought to gradually evolve into lasting traits.

From an empirical standpoint, one way to conceptualize these various meditative traits is to view them as developmental changes in physiological baselines in the organism. Finding ways of systematically characterizing these baselines before, during, and after mental training is thus crucial for the empirical examination of the long-term impact of meditation. A systematic characterization of baselines in the context of meditation is also an important methodological issue because an essential aspect of experimental research is the identification and control of a baseline against which the condition of interest can be contrasted. Underestimating this issue is a potential source of confusion when studying meditation practitioners, particularly long-term practitioners, because the contrast between the initial baseline and the meditative state might be biased by a baseline difference between groups (i.e., novices versus adepts).

When conceptualizing the notion of a baseline, perhaps the most useful approach is to consider a baseline in terms of the capacity for living systems to maintain their identity despite the fluctuations that affect them. Indeed, for many theorists this ability is one of the most fundamental biological roots of individuality, if not subjectivity itself (Maturana & Varela, 1980). This basic notion of homeostatic identity is the intuition that underlies the concept of a baseline in various domains. In the context of meditation, the notion of a baseline is clearly meaningful in relation to "raising the baseline" by developing traits that persist outside of any meditative state. In the scientific context, the concept of a baseline plays an important role in characterizing a broad variety of biological phenomena. Similarly, in psychology a baseline state is defined as a resting state by comparison to a task-specific state (say the task of remembering a succession of numbers). In an even broader, ecological context, psychologists attempt also to identify regularities or traits in the average ongoing states of an individual (e.g., mood and personality). Areas of biology that study living processes at a systemic level – such as the level of the cell, the organism, or the immune system – also use the notion of the baseline to convey the idea that something remains constant in the system through time. Such features would include, for example, the electrical charges of the neuron, the glucose level in the blood system, and body temperature. It is important to note that, in all these contexts, the functional invariance of a given baseline provides information about the homeostatic mechanisms that regulate and maintain the organization of the system even amid environmental perturbations. It is in this sense that the notion of a baseline is related to the ongoing identity of an organism. And given the sensitivity that most contemplative traditions show to this type of issue, the search for baseline changes throughout the continuum of mental training is a general strategy that can potentially be applied to clarify mind-brain-body interactions at many explanatory levels, including brain chemical, metabolic, or electrical activity; the immune system; the cardiovascular system; and the hormonal system.

This idea can be illustrated with the case of metabolic and electrical brain baselines. Investigation of the metabolic brain baseline began following the finding that in an awake resting state, the brain consumes about 20% of the total oxygen used by the body, despite the fact that it represents only 2% of the total body weight (Clark & Sokoloff, 1999). This finding raises the question of the functional significance of this ongoing consumption of energy by the brain. Interestingly, brain imaging techniques that permit an examination of baseline levels of brain activity have suggested that this global activation at rest is not homogeneously localized in the brain. There are a consistent set of brain areas active at rest with eyes closed, as well as during visual fixation and the passive viewing of simple visual stimuli. The role of these activated areas is revealed from the attenuation of their activity during the performance of various goal-directed actions. Because the activity in these areas is associated with the baseline activity of the brain in these passive conditions, Raichle and colleague have suggested that they are functionally active, although they are not "activated" (Gusnard & Raichle, 2001). In contrast to the transient nature of typical activations, the presence of this functional activity in the baseline implies the presence of sustained information processing.

Our current understanding of the functional role of these tonically active networks is still limited. Evidence from brain imaging indicates that the posterior part of this tonically activated network (posterior cingulate cortex, precuneus, and some lateral posterior cortices) is important for the continuous gathering of information about the world around and possibly within us, whereas the anterior part (ventro- and dorsoventral prefrontal cortices) is important for the ongoing association among sensory, emotional, and cognitive processes that participate in spontaneous self-referential or introspectively oriented mental activity (Gusnard & Raichle, 2001). One can speculate that, given the nature of many meditations, these brain areas activated in the resting brain will be functionally affected by long-term meditative practices.

Similarly, the awake, resting brain is associated with a well-defined neuroelectric oscillatory baseline different from the one during sleep, anesthesia, or active mental activity. Changes in this baseline index are implicated in developmental processes in children, aging, cognitive IQ, and mental disorders (Klimesch, 1999). Along these same lines, we found a group difference in the initial premeditation baseline between long-term Buddhist practitioners and novices, suggesting some impact of long-term mental training (Lutz, Greischar, Rawlings, Ricard, & Davidson, 2004). The number of hours of formal meditation during the lifetime of long-term Buddhist practitioners correlates with some oscillatory properties of the brain electrical baselines. Furthermore, we showed that the post-meditation baseline was affected by the meditation session, and this suggests a short-term effect of meditation on the EEG baseline (Figure 19.4). In any case, this question of a neuroelectric baseline and its relation to mental training is a fruitful one, and it is currently being investigated, as is discussed in more detail in the next section.

To summarize, our functional understanding of the brain and body baselines remains largely incomplete, and given the importance played by some notion of a baseline in most meditative traditions, it is likely that our understanding will be significantly advanced by understanding those meditative practices that, above all else, aim to transform the "baseline of the mind."

Neuroelectric and Neuroimaging Correlates of Meditation

The search for the physiological correlates of meditation has been centered essentially on three groups: Yogis and students of Yoga in India, adherents of Transcendental Meditation (TM; Becker & Shapiro, 1981) in the United States, and practitioners of Zen and Tibetan Buddhism in Japan, the United States, and South Asia (India, Nepal). Historically, the first studies took place in Asia in the 1950s with advanced yogic practitioners in India (Das & Gastaut, 1955) and with long-term Zen practitioners in Japan (Kasamatsu & Hirai, 1966). Since the 1970s, meditation research has been done almost exclusively in the United States on practitioners of TM (Becker & Shapiro, 1981); over 500 studies have been conducted to date. Compared to the degree and sophistication of the training of practitioners in the early studies conducted in Asia, TM research relied mainly on the experience of relatively novice Western practitioners using mostly a single standard relaxation technique.

Since the late 1990s, we have witnessed a renewed interest in research on meditation. Various researchers have begun the exploration of a broad range of meditative practices inspired by various traditions – such as Zen, Tibetan Buddhism, Yoga, and Qi-gong – involving novices, patients, or long-term practitioners. Academic research institutions are starting to express an interest in this area as epitomized by the Mind and Life meetings at MIT in 2003 and a meeting co-sponsored by the John Hopkins School of Medicine and the Georgetown School of Medicine in November 2005 between the Dalai Lama, along with other Buddhist scholars, and neuroscientists (Barinaga, 2003).

This new, broad interest has been fostered by several factors. First, the neurobiology of consciousness and cognitive, affective, and social neuroscience have become central and accepted areas of research in neurosciences over the last two decades, which lends legitimacy to the research on meditation.

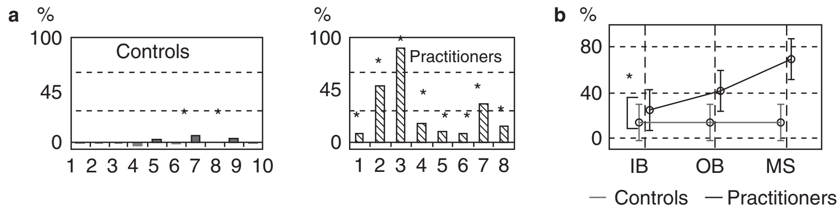

Figure 19.4. Relative EEG gamma power during non-referential compassion meditation in a group of novices and a group of long-term Buddhist practitioners. a–b. Intra-individual analysis on the ratio of gamma (25–42 Hz) to slow oscillations (4–13 Hz) averaged through all electrodes. a. The abscissa represents the subject numbers, the ordinate represents the difference in the mean ratio between the initial state and meditative state, and the black and red stars indicate that this increase is greater than two and three times, respectively, the baseline standard deviation. b. Interaction between the subject and the state factors for this ratio (ANOVA, $F(2,48) = 3.5$, $p < .05$). IB (initial baseline), OB (ongoing baseline) and MS (Fischer, 1971 #68). The relative gamma increase during meditation is higher in the post-meditation session. In the initial baseline, the relative gamma is already higher for the practitioners ($p < .02$) than the controls and correlates with the length of the long-term practitioners' meditation training through life (adapted from Lutz et al. 2004).

Second, because meditative practices, such as Yoga or Mindfulness-Based Stress Reduction (MBSR), are now used routinely in the medical environment, clinicians recognize the need to validate its impact on the brain and the body.

Neuroelectric Correlates of Meditative States

Since 1950s, the electrophysiological measure of brain or autonomic system has been the most popular imaging tool with which to study meditation.

Electroencephalography (EEG: Cooper et al., 2003) is a non-invasive technique that measures the electrical potentials on the scalp. EEG has an excellent temporal resolution in the millisecond range that allows the exploration of the fine temporal dynamic of neural processes. Below we discuss some basic findings about the nature and function of brain oscillatory processes as measured by electrophysiology, present some common theoretical assumptions about the neurodynamic basis of consciousness, and review the neuroelectric correlates of various meditative styles.

OSCILLATORY NEURAL SYNCHRONY AND CONSCIOUSNESS

In 1929, Hans Berger recorded for the first time a human brain's EEG and reported the presence of several brain rhythms in these signals (Berger, 1929). Since Berger's first observation, the various ongoing brain oscillations have been used successfully to characterize mental states, such as sleep, the waking state, or vigilance, and mental pathologies, such as epilepsy. Sensory evoked potentials (EEG signals triggered by an external stimulation) or the Bereitschaftpotential (a "readiness EEG potential" that can be recorded over motor areas up to 1 s before the execution of a movement) have demonstrated that such mental factors as sensation, attention, intellectual activity, and the planning of movement all have distinctive electrical correlates at the surface of the skull (Zeman, 2001).

Even though EEG results may be also contaminated by muscle activity, EEG oscillations are believed to reflect mostly the post-synaptic activity of neurons, in particular from the neocortex. More precisely, when a large population of neurons recorded by a single electrode transiently oscillates at the same frequency with a common phase, their local electric fields add up to produce a burst of oscillatory power in the signal reaching the electrode (Nunez, Wingeier, & Silberstein, 2001). The amplitude, or power, of these EEG oscillations thus provides a coarse way to quantify the synchronization of a large population of oscillating neurons below an electrode.

Oscillatory neural synchrony is a fundamental mechanism for implementing coordinated communication among spatially distributed neurons. Synchrony occurs in the brain at multiple spatial and temporal scales in local, regional, and long-range neural networks. At the cellular level, oscillatory synchrony, or phase synchrony, refers to the mechanism by which a population of oscillating neurons fires their action potentials in temporal synchrony with a precision in the millisecond range. At the population level, neuronal synchrony is best analyzed by looking at the common average oscillatory neural activity among the population. This oscillatory activity can be measured either from the local field potentials (the summated dendritic current of local neural groups) or from the macroscale of scalp recordings in EEG (Becker & Shapiro, 1981) and magnetoencephalography (MEG); Srinivasan et al., 1999). The emergence of synchrony in a neural population depends on the intrinsic rhythmic properties of individual neurons, on the properties of the network (Llinas et al., 1998), and on the inputs delivered to the network. As a general principle, synchrony has been proposed as a mechanism to "tag" the spatially distributed neurons that participate in the same process and, consequently, to enhance the salience of their activity compared to other neurons (Singer, 1999).

The functional and causal roles of synchrony are still an active area of research and depend on the spatial scale at which these phenomena are analyzed. In particular, it is useful to distinguish between two main scales, short range and long range. Short-range integration occurs over a local network (e.g., columns in the primary visual cortex), distributed over an area of approximately 1 cm, through monosynaptic connections with conduction delays of 4 to 6 ms. Most electrophysiological studies in animals have dealt with short-range synchronies or synchronies between adjacent areas corresponding to a single sensory modality. These local synchronies have usually been interpreted as a mechanism of perceptual binding – the selection and integration of perceptual features in a given sensory modality (e.g., visual Gestalt features).

Large-scale integration concerns neural assemblies that are farther apart in the brain and are connected through polysynaptic pathways with transmission delays longer than 8 to 10 ms (Schnitzler & Gross, 2005; Varela et al., 2001). In this case, synchrony cannot be based on the local cellular architecture, but must instead reside in distant connections (cortico-cortical fibers or thalamocortical reciprocal pathways). These pathways correspond to the large-scale connections that link different levels of the network in different brain regions to the same assembly. The underlying mechanism of long-range synchrony is still poorly understood (for a model see Bibbig, Traub, & Whittington, 2002). Long-range synchronization is hypothesized to be a mechanism for the transient formation of a coherent macro-assembly that selects and binds multimodal networks, such as assemblies between occipital and frontal lobes, or across hemispheres, which are separated by dozens of milliseconds in transmission time. The phenomenon of large-range synchrony has received considerable attention in neuroscience because it could provide new insights about the emergent principles that link the neuronal and the mental levels of description. Several authors have proposed that these mechanisms mediate several generic features of consciousness, such as unity (Varela & Thompson, 2001), integration and differentiation (Tononi & Edelman, 1998), transitoriness and temporal flow (Varela, 1999), and awareness of intentional action (Freeman, 1999). In this view, the emergence of a specific coherent global assembly underlines the operation of any moment of experience. The transition from one moment to the next would be subserved by desynchronization of some coherent assemblies and the synchronization of new ones. It has also been hypothesized that whether a local process participates directly in a given conscious state depends on whether it participates in a coherent, synchronous global assembly (Dehaene & Naccache, 2001; Engel et al., 2001).

Neural synchronies occur in a broad range of frequencies. Fast rhythms (above 15 Hz) in gamma and beta frequencies meet the requirement for fast neural integration and thus are thought to play a role in conscious processes on the time scale of fractions of a second (Tononi & Edelman, 1998; Varela, 1995). Fast-frequency synchronies have been found during such processes as attention, sensory segmentation, sensory perception, memory, and arousal.

Yet neural synchrony must also be understood in the context of the slower alpha and theta bands (4–13 Hz), which play an important role in attention, working memory (Fries, Reynolds, Rorie, & Desimone, 2001; von Stein, Chiang, & Konig, 2000), and sensorimotor integration (Burgess & O'Keefe, 2003; Rizzuto et al., 2003). This evidence supports the general notion that neural synchronization subserves not simply the binding of sensory attributes, but the overall integration of all dimensions of a cognitive act, including associative memory, affective tone and emotional appraisal, and motor planning.

So far, oscillatory synchrony has been investigated mostly on oscillatory signals having the same rhythms. More complex non-linear forms of cross-band synchronization, so-called generalized synchrony (Schiff, So, Chang, Burke, & Sauer, 1996), are also expected and may indeed prove more relevant in the long run to understanding large-scale integration than strict phase synchronization (Le Van Quyen, Chavez, Rudrauf, & Martinerie, 2003).

Considering the general importance of neural synchrony in brain processing, it is not surprising that scientists interested in meditation have tried to study its electrical brain correlates as early as the 1950s (Das & Gastaut, 1955; Wenger & Bagchi, 1961). Since then, more than 100 studies have investigated the tonic changes in the ongoing EEG from a restful state to a meditative state or the modulatory, or phasic, effect of meditation on the electrical brain responses to external sensory stimuli (for reviews, see Andresen, 2000; Davidson, 1976; Delmonte, 1984; Fenwick, 1987; Pagano & Warrenburg, 1983; Schuman, 1980; Shapiro & Walsh, 1984; West, 1980, 1987; Woolfolk, 1975).

The majority of these EEG studies focused on the change in the brain's oscillatory rhythms, particularly in the slow frequencies (alpha and theta rhythms). It is important to keep in mind that such measures reflect extremely blurred and crude estimates of the synchronous processes of the $\sim 10^{11}$ neurons in a human brain. Because slow oscillations have high electrical voltages that make them visually detectable, early studies only reported coarse visual descriptions of EEGs. Changes in fast-frequency oscillations during meditation have been rarely reported (with the notable exception of Das & Gastaut, 1955, and more recently Lutz et al., 2004) possibly because the lower voltage of these oscillations requires spectral analysis instead of simple visual inspection. The investigation of fast-frequency synchrony during meditation has become more common since the 1990s following a developing understanding of its functional role in the "binding problem."

In addition to spectral analysis, meditation has also been characterized with measures of coherence or long-distance phase synchrony (LDS) (Fries et al., 2001). These measures quantify the dynamic coupling between EEG channels over distant brain regions. Coherence is the frequency correlation coefficient, and it represents the degree to which the frequency profiles of two distant areas of the head, as reflected in the electrical signals detected by scalp electrodes, are similar. LDS measures the instantaneous phase relationship between signals at a given frequency (Lachaux, Rodriguez, Martinerie, & Varela, 1999). LDS provides a more direct measure of phase-locking than coherence because it can separate the effects of amplitude and phase in the interrelations between signals. Thus, LDS can test more precisely the assumption that phase synchrony is involved in long-distance neuronal integration. Because of the non-linear nature of brain processes, these linear analysis approaches are likely to characterize only partially the functional properties of synchronous activity. Yet, complementary non-linear analysis of brain dynamics during meditation has only just started to be explored (Aftanas & Golocheikine, 2002).

In the selective summary of the literature below, we review only those EEG studies published in top-tier journals and/or those that focused on the study of long-term practitioners.

TRANSCENDENTAL MEDITATION

TM is a passive meditation adapted for Westerners from the Vedic or Brahmanical traditions of India. The subject sits quietly, with the eyes closed, repeating a Sanskrit sound (mantra), while concentrating on nothing and letting the mind "drift" (Morse, Martin, Furst, & Dubin, 1977). The continued practice of TM supposedly is said to lead to an expansion of consciousness or the attainment of "cosmic" or "pure, self-referral consciousness" (Maharishi, 1969). The technique is described as "easy, enjoyable and does not involve concentration, contemplation or any type of control" (R. K. Wallace, 1970).

The standard EEG correlate of TM is an increase in alpha rhythm amplitude, frequently followed by a slowing in frequency by 1–3 Hz and a spreading of this pattern into the frontal channels (R. K. Wallace, 1970). An increase in bursts of theta oscillations (4–7 Hz) has also been reported. Global fronto-central increases in coherence in alpha (6–12 Hz), as well as in theta frequency ranges between baseline and TM practice, have been found frequently (for reviews and for a model of TM practice see Travis, Arenander, & DuBois, 2004)).

The dominant frequency in the scalp EEG of human adults is the alpha rhythm. It is manifest by a peak in spectral analysis around 10 Hz and reflects rhythmic alpha waves (Klimesch, 1999; Nunez et al., 2001). Alpha oscillations are found primarily over occipital-parietal channels particularly when the eyes are closed, yet alpha activity can be recorded from nearly the entire upper cortical surface. During wakefulness, it is a basic EEG phenomenon that the alpha peak reflects a tonic large-scale synchronization of a very large population of neurons. This low-frequency global neural activity is thought to be elicited by reciprocal interactions among the cortex, the reticular nucleus, and the thalamocortical (Delmonte, 1985) cells in other thalamic nuclei (Klimesch, 1999; Nunez et al., 2001; Slotnick, Moo, Kraut, Lesser, & Hart, 2002) even if cortico-cortical mechanisms also play a possible role (Lopes da Silva, Vos, Mooibroek, & Van Rotterdam, 1980).

Because an overall decrease in alpha power has been related to increasing demands of attention, alertness, and task load, alpha activity is classically viewed as an "idling rhythm" reflecting a relaxed, unoccupied brain (Klimesch, 1999). Large-scale alpha synchronization blocks information processing because very large populations of neurons oscillate with the same phase and frequency; thus, it is a state of high integration but low differentiation. Within a bandwidth of perhaps 2 Hz near this spectral peak, alpha frequencies frequently produce spontaneously moderate to large coherence (0.3–0.8 over large interelectrode distance (Nunez et al., 1997). The alpha coherence values reported in TM studies, as a trait in the baseline or during meditation, belong to this same range. Thus a global increase of alpha power and alpha coherence might not reflect a more "ordered" or "integrated" experience, as frequently claimed in TM literature, but rather a relaxed, inactive mental state (Fenwick, 1987).

In contrast, alpha desynchronization reflects actual cognitive processes in which different neuronal networks start to oscillate locally at different frequencies – typically in higher frequencies (>15 Hz), as well as slower rhythms (4–15 Hz) – and with different phases, reflecting local processing of specialized neuronal circuitries, such as those for attention, vision, memory, emotion, and so on. Large-scale synchrony between distant neuronal assemblies oscillating at various frequencies reflects an active coordination of functionally independent networks; in short, it reflects a state of high integration and high differentiation. Thus, the slow frequency activity (<13 Hz) found during TM meditation, combined with the frequent finding of decreased autonomic activity, has been interpreted by many authors as reflecting hypoarousal or a relaxed state (Delmonte, 1984; Holmes, 1984; Pagano & Warrenburg, 1983).

Yet, the "idling" model of alpha activity has been extended recently to account for new findings. Alpha oscillation can, paradoxically, increase locally over specific regions or also across specific areas while the subject is actively focusing his or her attention on an object or while holding in mind information (memory load during retention, for instance). Slow rhythms (4–12 Hz) can thus also be involved in active mental states requiring attention, working memory, or semantic encoding (Ward, 2003). This alpha model still remains compatible with the idling model because on this view, alpha rhythms during mental activity reflect active inhibition of non-task-relevant cortical areas (Klimesch, 1999).

Because TM is described as a passive meditation without active control or concentrative effort, the EEG picture found during TM meditation can still be interpreted as reflecting mainly hypoarousal or a relaxed state. Yet, it is also possible that the ongoing repetition of the mantra, which involves, for instance, some form of attention and working memory, can lead to an active exclusion of some brain processes compatible with an increase in alpha activity in non-task-related cortical territories.

TM researchers further view this EEG picture as reflecting a single and original state of "Transcendental pure consciousness" (Maharishi, 1969; Travis et al., 2004). The transcendental state is conceptualized as a "fourth state of consciousness," a "wakeful hypometabolic state" that differs from hypnosis and ordinary or sleep states (R. K. Wallace, 1970). Although these descriptions might best be interpreted as metaphysical assertions rather than first-person descriptions, they do suggest that this state of absorption could also involve some form of meta-awareness. Nevertheless, despite the possibility of a more sophisticated phenomenological interpretation and the need to relate physiological data to subjective data, it is still unclear whether and how TM meditation practices produce increased alpha activity beyond a general arousal effect or an inhibition of task-irrelevant cortical zones. Other relaxation techniques have led to the same EEG profile, and studies that employed counter-balanced control relaxation conditions consistently found a lack of alpha power increases or even decreases when comparing relaxation or hypnosis to TM meditation (Morse et al., 1977; Tebecis, 1975; Warrenburg, Pagano, Woods, & Hlastala, 1980). Similarly, the initial claim that TM produces a unique state of consciousness different from sleep has been refuted by several EEG meditation studies that reported sleep-like stages during this technique with increased alpha and then theta power (Pagano, Rose, Stivers, & Warrenburg, 1976; Younger, Adriance, & Berger, 1975).

To summarize, alpha global increases and alpha coherence mostly over frontal electrodes are associated with TM practice when meditating compared to baseline (Morse, Martin, Furst, & Dubin, 1977). This global alpha increase is similar to that produced by other relaxation techniques. The passive absorption during the recitation of the mantra, as practiced in this technique, produces a brain pattern that suggests a decrease of processing of sensory or motor information and of mental activity in general. Because alpha rhythms are ubiquitous and functionally non-specific, the claim that alpha oscillations and alpha coherence are desirable or are linked to an original and higher state of consciousness seem quite premature.

Attention Meditation with an Object

This section regroups EEG studies on meditative practices having a component of attention regulation. In all these practices, the intentional structure of a subject/object remains. As mentioned earlier these techniques lie somewhere on a continuum between two poles of practices: On the one hand, one-pointed attention techniques cultivate a form of voluntary, effortful, and sustained attention on an object, and on the other hand, *vipaśyanā* meditation cultivates a more broadly focused, non-judgmental mode of bare attention. These meditations differ from relaxation techniques because they cultivate a balance between hypoarousal (Becker & Shapiro, 1981) and excitation. This balance is required, in particular, to maintain a sufficient clarity or meta-awareness throughout the meditative session. These practices encompass, for instance, Zazen meditation, Indian yogic concentration, meditation in MBSR, and one-pointed focused attention. The emphasis on stabilizing the mind on an object or on the awareness of the intentional relation itself depends not only on the given technique but also likely on the degree of the practitioner's accomplishment in a given practice.

With some important exceptions, most studies on Zazen or India yogic concentration practices have revealed an EEG signature similar to TM as characterized by lowered autonomic arousal and slow-frequency EEG patterns (either an increase in alpha or an increase in theta activity; Austin, 1998; Delmonte, 1984; Fenwick, 1987; Shapiro & Walsh, 1984). This pattern was reported as a state and sometimes also a trait. For instance, Kasamatsu and Hirai measured the EEG signals of 48 priests and disciples during Zazen practices (Kasamatsu & Hirai, 1966). All subjects exhibited visually an increase in alpha activity mostly over central and frontal electrodes immediately after beginning meditation. Less experienced subjects tended to maintain high-amplitude alpha activity throughout the meditative session, whereas the EEGs of those with more years of Zazen practice showed a rhythmical theta wave pattern during the later stage of Zazen Anand, Chhina, and Singh (1961) compared visually the EEG activity of four advanced yogis during rest and during meditation. All subjects displayed large alpha activity during periods of rest and increases during meditation (Anand et al., 1961).

Yet, several exceptions deserve scrutiny. Two early field studies of Yoga in India by Das and Gastaut (1955) and Wenger and Bagchi (1961), reported a clear sign of autonomic arousal with increased heart rate and skin conductance while advanced yogis meditate. High-amplitude high-frequency EEG oscillations (beta and gamma) were found and were more pronounced during deep meditation (Das & Gastaut, 1955). In a well-controlled study, Corby et al. (1978) studied a form of Tantric Yoga meditation where the practitioners and controls focused on their breath and on the mantra. Unlike previously reported studies, proficient meditators demonstrated increased autonomic activation during meditation, whereas unexperienced meditators demonstrated autonomic relaxation. During meditation, proficient meditators showed an increase in alpha and theta power, minimal evidence of EEG-defined sleep, and a decrease in autonomic orienting to external stimulation.

These findings are consistent with the view described above that alpha and theta activation can also index attentional processes. Becauseee one major feature of attention is selection, it is likely that the localized increases in slow frequencies reflect cortical tuning such that those cortical zones that are not required for task engagement are selectively inhibited to facilitate task performance (see e.g., Cooper et al., 2003). Also consistent with this formulation are data on attentional anticipation. Foxe, Simpson, and Ahlfors (1998) demonstrated that a cue indicating an upcoming auditory stimulus induced increased alpha power over parieto-occipital (Blake & Logothetis, 2002) cortex, compared when the cue indicated an upcoming visual stimulus. These findings are all consistent with the idea that alpha synchronization during attentional processes reflects inhibition of non-relevant areas or process (Klimesch, 1999).

It would be misguided to identify alpha or theta activity as the sole index of mindfulness/awareness meditation. Numerous data

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suggest that synchronized gamma activity is also specifically involved in selective attention. In the literature on meditation, one early study on advanced yogic practitioners reported spectacular generalized high-amplitude beta/gamma oscillations during intense internal concentration of attention (Das & Gastaut, 1955). We also found an increase in fast-frequency oscillations during *samatha* practice (unpublished data). Numerous studies of humans, as well as animals, have demonstrated an enhancement of the gamma activity when subjects were actively attending to a certain stimulus or simply perceived an object (Tallon-Baudry & Bertrand, 1999). Such synchronized gamma activity during attention participates not only in bottom-up processes (e.g., sensory segmentation, feature extraction) but also in top-down processes (Engel et al., 2001).

Slow and fast-frequency rhythms interact in the brain. For instance, in intracranial recordings from area V4 in monkeys, increased gamma range synchronization, but reduced low-frequency synchronization, is observed among neurons activated by the attended stimulus as compared to neurons activated by an identical but non-attended stimulus (Fries et al., 2001). These important results, as well as event-related data, lead to the notion of a *surround inhibition* wherein active cortical areas, indexed by alpha desynchronization and/or fast-frequency synchronies, are surrounded by a "doughnut" of alpha synchronization or inhibition (Suffczynski, Kalitzin, Pfurtscheller, & Lopes da Silva, 2001). This balance between slow and fast frequencies can be detected under specific experimental conditions, such as intracranial recording or simple event-related tasks, over motor or sensory areas. Yet, this distinction is likely to be blurred in general while recording ongoing EEG signals because of volume conduction (i.e., a single neural source is likely to influence the signal in many recording channels). Despite this limitation, the combined characterization of fast-frequency synchronies, in addition to the slow frequencies, over various topographical regions of the scalp is likely to provide increased understanding of the specific neural processes that are altered by these practices.

Finally there is some evidence that alpha/theta oscillations during Zazen or Samadhi practices differ functionally from the alpha/theta activity during a relaxed non-meditative state. An early model of meditation proposed that "de-automization" was induced, such that each stimulus trial was perceived as "fresh" during meditative states cultivating a receptive and open awareness (Deikman, 1966; Kasamatsu & Hirai, 1966). A possible indication of this process is EEG alpha blocking, which is defined as a decrease in ongoing alpha (8–12 Hz) power when comparing prestimulus to post-stimulus activity. Typically alpha activity is reduced from closed eyes to open eyes or when discrete stimuli are presented and is thought to reflect cortical processing. This response habituates after repetitive stimulus presentations (Morrell, 1966). Early field studies on yogis reported no alpha blocking in response to auditory, thermal, and visual stimuli (Anand et al., 1961; Das & Gastaut, 1955; Wenger & Bagchi, 1961). Subsequent Zen studies found alpha blocking to auditory sounds but without habituation (Kasamatsu & Hirai, 1966). Early TM studies produced conflicting results, with one finding an absence of alpha blocking, whereas the other reported habituation of alpha blocking to auditory stimuli (Banquet, 1973; R. K. Wallace, 1970).

A replication and extension of these findings were attempted (Becker & Shapiro, 1981). Experienced Zen, Yoga, and TM meditators, and "attend" and "ignore" groups of controls were presented with auditory clicks during mediation. The attend group was asked to "pay strong attention" to each click, notice all of its sound qualities and subtleties, and count the number of clicks; the ignore group was told "try not to let the clicks disturb your relaxed state." EEG alpha suppression and skin conductance response both showed clear habituation, which did not differ among groups, thus failing to replicate the earlier studies.

As a summary, these meditation practices that feature focused attention on objects most frequently are accompanied by increases in alpha and theta power, but also by fast frequencies (beta and gamma) during deep meditation. The slow-frequency activity overlaps notably with early drowsiness and sleep stages even if these oscillations potentially differ functionally. The neuroelectric signatures of these various meditative techniques (Focus Attention, Zazen, Vipaśyanā meditation) have not yet been firmly established. Our current understanding of attention suggests that the selection or the exclusion from attention of particular contents (sensory, motor, internal tasks) is correlated with the activation or inhibition of specific brain areas, as indexed by specific changes in selective brain oscillatory patterns. The combination of topographical information with spectral information seems a promising method by which to delineate further these various meditative techniques.

OBJECTLESS MEDITATION

During objectless meditation, such as Open Presence or Non-Referential Compassion meditation, it is said that the practitioner does not focus on a particular object but rather cultivates a state of being. Objectless meditation does so in such a way that, according to reports given after meditation, the intentional or object-oriented aspect of experience appears to dissipate in meditation along with the explicit sense of being a perceiver or an agent (autobiographical self). One working hypothesis is that some form of meta-awareness or, more precisely, of some mere ipseity still remains or is enhanced during these states.

These types of meditation have been poorly investigated so far. We studied a group of long-term practitioners who underwent mental training in the same Tibetan Nyingmapa and Kargyupa traditions for 10,000 to 50,000 hours over time periods ranging from 15 to 40 years. We found that these long-term Buddhist practitioners self-induced sustained EEG high-amplitude gamma-band oscillations and phase synchrony during Non-Referential Compassion meditation (Lutz et al., 2004, Figure 19.5). These fast-frequency oscillations (>20 Hz) had a peak-to-peak amplitude of the order of dozens of microvolts for several practitioners. High-amplitude oscillations were continuous during the meditation over several dozens of seconds and gradually increase during the practices. These EEG patterns differ from those of controls, in particular over lateral fronto-parietal electrodes. Some preliminary data further suggest that these ongoing high-amplitude gamma oscillations are correlated with self-reports of the clarity (see the section on *samatha* and *vipaśyanā* as paradigms of meditation; Lutz et al., 2005).

These new findings are similar to the early report of Das and Gastaut (1955) during the Samadhi of advanced Indian Yogis. Samadhi was defined as a state during which "the perfectly motionless subject is insensible to all that surrounds him and is conscious of nothing but the subject of his meditation." Das and Gastaut (1955) reported an acceleration of the cardiac rhythm during meditation almost perfectly parallel to that of the EEG. The EEG showed progressive and spectacular modifications during the deepest meditations in those subjects who had the longest training: acceleration of the alpha rhythm and decrease in the amplitude and appearance of faster oscillations (>20 Hz). These fast frequencies (beta (25–30 Hz) and sometimes even gamma activity (40–45 Hz) became generalized during the Samadhi meditation, with high amplitude reaching between 30–50 mV.

In our study (Lutz et al., 2004), we further showed that during this objectless meditation the ratio of fast-frequency activity (25–42 Hz) to slow oscillatory activity (4–13 Hz) over medial fronto-parietal electrodes is initially higher in the resting baseline before meditation for the practitioners than the controls (Figure 19.4). During meditation, this difference increases sharply over most of the scalp electrodes and remains higher than the initial baseline in the post-meditative baseline. The functional and behavioral consequences of sustained gamma activity during objectless meditation are not currently known, and such effects clearly need further study.

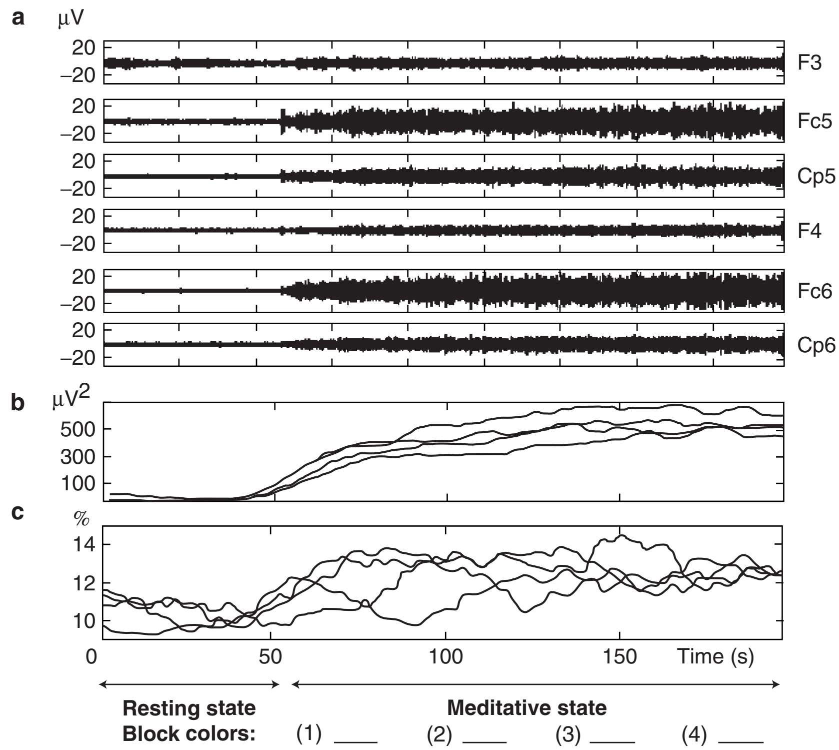

Figure 19.5. Example of high-amplitude gamma activity during the non-referential compassion meditation of long-term Buddhist practitioners. **a**. Raw electroencephalographic signals. At t = 45 s, practitioner S4 started generating a state of non-referential compassion, block 1. **b**. Time course of gamma activity power over the electrodes displayed in "a" during four blocks computed in a 20-s sliding window every 2 s and then averaged over electrodes. **c**. Time course of their cross-hemisphere synchrony between 25–42 Hz. The density of long-distance synchrony above a surrogate threshold was calculated in a 20-ssliding window every 2 s and for each cross-hemisphere electrode pairs and, then, was averaged across electrode pairs (adapted from Lutz et al. 2004).

Neuroimaging Correlates of Meditation

At this stage neuroimaging studies on meditation are typically more exploratory than hypothesis driven. Nevertheless, some progress has been made in the identification of structural-functional brain relationships of meditative states and traits using a variety of neuroimaging modalities. In particular, some theoretical efforts have been made to localize the neural circuitry selectively engaged during a meditative state. Austin (1998), for instance, elegantly combined his insight as a Zen practitioner with his neuroanatomical knowledge of the brain as a medical doctor to speculate about the neural basis of the peak experience of a meditative state termed "kensho" or "satori" in Japanese Zen Buddhism. In this state, the sense of selfhood is allegedly dissolved and an "unattached, self-less, impersonal" awareness remains (this state shares a strong, descriptive similarity with the Open Presence state discussed above). After examining the precise experiential changes induced by this state, he reviewed the various physiological subsystems that might participate in this state. Austin specifically introduces the distinction between "egocentric" neural networks involved in the generation of a multifaceted self situated in time and space and "allocentric" neural networks involved in the mere processing of the external environment. For Austin, neural networks participating in the construction of the narrative self could be shut down during Kensho, specifically through thalamic gating originating from the reticular formation. At the same time, he proposes that the state of hyperawareness during this practice is mediated by intralaminar nuclei of the thalamus that can increase the fast-frequency synchrony in other cortical regions. These nuclei could shape the resonance of the cortico-thalamo-cortical loops and functionally alter the neural processing in these egocentric/allocentric networks. These proposals (Austin, 1998, 2006) are clearly speculative, and further discussion is beyond the scope of this review. Nevertheless, Austin's work amply illustrates the potential benefits that may come when the neuroscience of meditation and first-person descriptions are brought into a dynamic dialogue that combines their findings in a manner that places fruitful constraints on each.

Although there is considerable potential for advancement in neuroscience through neuroimaging studies of meditation, the number of published studies remains sparse. To illustrate the range of methods and questions utilized thus far, we now review briefly the published research in this area.

Brain Imaging Techniques Used in Meditation Research

Positron emission tomography (PET; Blake & Logothetis, 2002) and functional magnetic resonance imaging (fMRI) are two functional brain imaging methods that have been used to study meditation. PET measures emissions from radioactively labeled chemicals that have been injected into the bloodstream and uses the data to produce two- or three-dimensional images of the distribution of the chemicals throughout the brain and body. Using different tracers, PET can reveal blood flow, oxygen and glucose metabolism, and neurotransmitter concentrations in the tissues of the working brain. Blood flow and oxygen and glucose metabolism reflect the amount of brain activity in different regions, and this type of data enables scientists to characterize the physiology and neurochemistry of the working brain. SPECT (single photon emission computed tomography) is another neuroimaging method that is similar to, though less sophisticated than PET, and it produces images of neurochemical function that have less spatial resolution than PET. MRI uses magnetic fields and radio waves to produce high-quality two- or three dimensional images of brain structures without injecting radioactive tracers. Using MRI, scientists can see both surface and deep brain structures with a high degree of anatomical detail (millimeter resolution). MRI techniques can also be used to image the brain as it functions.

Functional MRI (fMRI) relies on the magnetic properties of blood to enable the researcher to measure the blood flow in the brain as it changes dynamically in real time. Thus researchers can make maps of changes in brain activity as participants perform various tasks or are exposed to various stimuli. An fMRI scan can produce images of brain activity as fast as every second or two, whereas PET usually takes several dozens of seconds to image brain function. Thus, with fMRI, scientists can determine precisely when brain regions become active and how long they remain active. As a result, they can see whether brain activity occurs simultaneously or sequentially in different brain regions as a participant thinks, feels, or reacts to external stimuli. An fMRI scan can also produce high-quality images that can identify more accurately than PET which areas of the brain are being activated. In summary, fMRI offers better image clarity along with the ability to assess blood flow and brain function in seconds. So far, however, PET retains the advantage of being able to pinpoint which neurochemicals are involved in functional brain alterations.

Early Neuroimaging Studies on Relaxation Practice and Meditation

The studies from Lou et al. (1999) and Newberg et al. (2001) provide the first evidence of functional brain changes using PET or SPECT during a relaxation practice and a meditative practice, respectively. Even if these studies offer new insights about these states, they speak also for the need to more precisely develop descriptions of the practices to better understand just what the functional neural changes are reflecting.

Yoga Nidrā, literally "Yoga-Sleep," is a state in the Yoga tradition in which consciousness of the world and consciousness of action are meant to be dissociated: The mind "withdraws" from wishing to act and is not associated with emotions or the power of will. The practitioner allegedly becomes a neutral observer who experiences the loss of conscious control, concentration, or judgment, yet maintains an equal and impartial attention to sensory awareness, which is said to be enhanced. A PET ($^{15}O\text{-}H_2O$) study of blood flow changes during Yoga Nidrā practice was carried out while subjects listened to a tape recording, with guided instructions on the different phases of the practice (Lou et al., 1999). The relaxation tape contained focusing exercises on body sensation, abstract joy, visual imagery of a summer landscape, and symbolic representation of the self. Participants listened to the tape and followed the instructions of the guided meditation. The baseline condition was obtained by replaying the tape while participants remained neutral (i.e., they did not follow the instructions). Each of the guided meditation phases was associated with different regional activations during meditation relative to the control conditions. Yet, during all meditative phases, overall increases in bilateral hippocampus, parietal, and occipital sensory and association regions were found compared to control conditions. This pattern suggests an increase of activity in areas involved in imagery.

Deactivation was found during meditation in orbitofrontal, dorsolateral prefrontal, anterior cingulate cortices, temporal and inferior parietal lobes, caudate, thalamus, pons, and cerebellum. This differential activity was interpreted as reflecting a "tonic" activity during normal consciousness in the baseline condition. The areas decreasing during the meditation state are known to participate in executive function or control of attention. More particularly, dorsolateral prefrontal cortex participates in working memory and the preparation for voluntary movement, the anterior cingulate plays a role not only in motivation and resolution of conflict but also skeleto-motor control and executive attention, and the cerebellum is implicated in cognitive functions such as attention.

Lou et al. (1999) interpreted these results as reflecting dissociation between two complementary aspects of consciousness: the conscious experience of the sensory world and the "fact or illusion of voluntary control, with self regulation." Unfortunately, the lack of a control population makes it difficult to interpret whether the brain patterns reflect specific meditative qualities or the cognitive processes induced by the instructions.

Using SPECT Newberg et al. (2001) measured changes in regional blow flow (rCBF) while eight relatively experienced Tibetan Buddhist practitioners meditated. The practitioners practiced daily for at least 15 years and underwent several 3-month retreats. In the scanner, the practitioners were instructed to "focus their attention on a visualized image and maintained that focus with increasing intensity." In constrast to Lou et al. (1999), Newberg and colleagues (2001) reported an increase in activity in orbital frontal cortex, dorsolateral prefrontal cortex (DLPFC), and thalamus. They also found a negative correlation between the DLPFC and the superior parietal lobe, which was interpreted as reflecting an altered sense of space experienced during meditation. The difference in the frontal areas between their finding and that of Lou et al. (1999) was viewed as reflecting a difference between an active and a passive form of meditation.

In addition to the fact that no control participants were involved in the Newberg study, there is regrettably a lack of descriptive precision of the meditative state that was studied. This limitation will hamper the future comparison of this study with others. More precisely, a broad variety of Tibetan meditative techniques could encompass the provided meditative descriptions. These practices include, for instance, Focused Attention on a mental object, or any meditation on the visualization of a deity, or indeed the visualization of one's guru. Unfortunately, these practices can differ or even be opposite in terms of their motivations or emotional qualities. For instance, the visualization of deities could involve some invocation of anger or lust, whereas the visualization of the guru is meant to induce a strong devotional affect in the meditator. Because the independent variable (i.e., the specific meditative practice) was only vaguely described in this study, its impact is limited.

FOCUSED ATTENTION/MINFULNESS-AWARENESS MEDITATION

A form of Kundalini Yoga using mantra repetition combined with breath awareness was assessed with fMRI (Lazar et al., 2000). The control state entailed the mental enunciation of animal names. Five Yoga adepts who had practiced Kundalini Yoga for at least 4 years served as subjects. An increase in the Blood Oxygenation Level Dependent (BOLD) signal was found from baseline to meditation in the putamen, midbrain, anterior cingulate cortex, and the hippocampal/parahippocampal formation, as well as in regions in the frontal and parietal cortices. The comparison of early versus late meditation states showed activity increase in these regions, but within a greater area and with larger signal changes later in the practice. Because the pattern of brain activity increased with meditation time, it may index the gradual changes induced by meditation. This pattern of activity encompassed areas subserving attention (fronto-parietal cortices) and areas subserving arousal and autonomic control (limbic regions, midbrain, and anterior cingulate cortex).

In another attention-related study, we recently studied experienced Buddhist meditators (>10,000 hours of cumulative meditation practice) and newly trained control subjects while they performed a Focused Attention meditation *(Tsé-cig Ting-ngé-dzin*; see the section on Focused Attention), alternating with a passive state, while undergoing block-design fMRI (Brefczynski-Lewis, Lutz, & Davidson, 2004). During this standard meditation, the participants concentrated their attention on an external visual object (a white dot on the screen), gently bringing attention back to the object if they became distracted or sleepy. Control subjects with no prior meditative training were given instruction in concentration meditation with daily practice a week before the fMRI scan. fMRI of concentration meditation in both the experienced meditators and the controls showed common areas of activation in the traditional attention network, including such areas as the intraparietal sulci, frontal eye fields (FEF), thalamus, insula, lateral occipital, and basal ganglia. However, experienced meditators showed more activation, especially in the frontal-parietal network. The increased activation in these regions for experienced practitioners may represent a neural correlate for these subjects' expertise in sustained attention. The fact that controls show greater activation in the anterior cingulate compared with the adepts may reflect greater error proneness (i.e., distraction) and conflict monitoring in the controls than the adepts; the conflict would be between the instructions to focus and the difficulty of complying with such instructions.

Taken together these two brain imaging studies show that concentration meditation enhances processing in regions similar to those found in other attentional paradigms. The group differences between long-term practitioners and novices support the view that attention processing could be affected by mental training.

PURE COMPASSION AND LOVINGKINDNESS MEDITATION

Using functional imaging, we assessed brain activity while novice and long-term practitioners generated a Lovingkindness-Compassion meditation, alternating with a resting state (Brefczynski-Lewiset et al., 2004). As described in the section on Non-Referential Compassion meditation, this standard Buddhist meditation involves the generation of a state in which an unconditional feeling of lovingkindness and compassion pervades the whole mind as a

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way of being, with no other consideration, reasoning, or discursive thoughts. This state is called in Tibetan "pure" or "non-referential" compassion, as the practitioner is not focused upon particular objects during this state. In the resting state the subjects were asked to be in the most ordinary state without being engaged in an active mental state or being in a pleasant or unpleasant emotional state. Subjects were eight long-term Buddhist practitioners and eight age-matched healthy control volunteers who were interested in learning to meditate. Buddhist practitioners underwent mental training in the Tibetan Nyingmapa and Kargyupa traditions for 10,000 to 50,000 hours over time periods ranging from 15 to 40 years. During the meditative state, we found a common activation in the striatum, anterior insula, somatosensory cortex, anterior cingulate cortex, and left-prefontal cortex and a deactivation in the right interior parietal. This pattern was robustly modulated by the degree of expertise, with the adepts showing considerably more enhanced activation in this network compared with the novices.

These data provide evidence that this altruistic state involved a specific matrix of brain regions that are commonly linked to feeling states, planning of movements, and positive emotions. Maternal and romantic love have been linked in humans to the activation of the reward and attachment circuitries, such as the substantia nigra and the striatum (caudate nucleus, putamen, globus pallidus; Bartels & Zeki, 2004). Positive and negative emotions are expected to differentially activate the left and right prefrontal cortices, respectively, as suggested by lesion and electrophysiological data (Davidson, 2000). More generally, feeling states are thought to be mediated by structures that receive inputs regarding the internal milieu and musculoskeletal structures and include the brainstem tegmentum, hypothalamus, insula, and somatosensory and cingulate cortices (Damasio, 1999). This view has received some neuroimaging support in a task where subjects self-generate emotional states and more recently in studies using pain experience or interoceptive tasks (Craig, 2002).

Finally, love and compassion require an understanding of the feelings of others; hence, a common view is that the very regions subserving one's own feeling states also instantiate one's empathic experience of other's feelings. This framework derives from perception-action models of motor behavior and imitation. The key proposal is that the observation and imagination of another person in a particular emotional state automatically activate a similar affective state in the observer, with its associated autonomic and somatic responses. Thus, experienced and empathic pain commonly activated the anterior insula and rostral anterior cingulate cortex (Singer et al., 2004). The activation in the anterior insula was stronger for the practitioners, an area that some scientists have found to be involved in feelings. These data are consistent with the view that our experience of another's suffering is mediated by the same brain regions involved in the experience of our own pain.

We further found that brain activity for the long-term practitioners was greater than the novices in several of the commonly activated regions. These analyses indicate that the degree of training, as reflected in the hours of cumulative meditation experience, modulates the amplitude of activation in the brain areas commonly involved in this state.

To summarize, our study of Compassion meditation found activation in brain regions thought to be responsible for monitoring one's feeling state, planning of movements, and positive emotions. This pattern was robustly modulated by the degree of expertise. These data suggest that emotional and empathic processes are flexible skills that can be enhanced by training and that such training is accompanied by demonstrable neural changes.

General Conclusion

Overall, this chapter aimed to summarize the state of knowledge in neuroscientific research on meditation and to suggest potential avenues of inquiry illuminated by these initial findings. The first section discussed the need for more precise descriptions of meditative practices so as to define properly the practices that are the objects of scientific study. Following this recommendation, the Buddhist contemplative tradition was presented in detail as a canonical example. The main Buddhist theories of meditation were reviewed as well as the basic parameters that define most forms of Buddhist contemplative practice. In addition to suggesting an approach to defining and categorizing meditation, this section also aimed to underscore the difficulty of separating well-defined first-person descriptions of meditative states from other claims that, although apparently descriptive, are best understood as reflecting particular cultural or religious exigencies that are not strictly rooted in scientifically tractable observations. The choice to view a Buddhist claim as a first-person description of an actual state or as primarily a product of some religious and cultural rhetoric is certainly subject to debate and interpretation. Further developments will definitely be needed to delineate these distinctions. With these difficulties in mind, three standard Buddhist meditative states were described in detail, as well as the rationale for the cultivation of these states and the expected post-meditative effects. Some general guidelines were then proposed for developing a questionnaire to define more precisely a practice under examination. It is our hope that this first section will provide researchers with some theoretical and methodological principles to clarify and enhance future research on meditation.

The second section explored some scientific motivations for the neuroscientific examination of meditation in terms of its potential impact on the brain and body of long-term practitioners or its possible role in the neuroscientific study of subjective experience. After an overview of the mechanisms of neuroplasticity and mind-body interaction, we argued that mental training might have a long-term impact on the brain and body in a way that is beneficial for physical health, illness, and possibly well-being. We then suggested how the use of first-person expertise might foster our understanding of the neural counterpart of subjective experience. These intersections between neuroscience and meditation were separated here mainly for analytical purposes, but these heuristic distinctions implicitly suggest an important area of further research; namely, the interactions among the various themes of research. For instance, one question of interest will be to explore whether it is meaningful to study the alleged therapeutic or healing virtues of meditation as a variable of research in isolation from other issues. The interest in this question stems from the possibility that the beneficial changes found in practitioners of meditation are intrinsically dependent on other practices or virtues cultivated in their tradition, such as compassion, ethical behavior, or a first-person exploration of the nature of the self and external perception. Having suggested, in any case, the potentially fruitful exploration of meditation from a neuroscientific perspective, in the final section, we reviewed the most relevant neuroelectric and neuroimaging findings of research conducted to date. We anticipate that the renewed interest in research on meditation will probably extend and possibly modify this section within the near future.

As noted earlier, we chose to emphasize the practice of long-term Buddhist practitioners, in part because of the potential that a study of such practitioners might have to enhance our understanding of consciousness. Already we have some indication that experienced practitioners are able to provide repeatable subjective reports that are more reliable than those from untrained persons, and this opens the door to wide-ranging research into the neural correlates of those reportable states. More particularly, the possibility that some meditators may be able to induce a state approaching some form of bare consciousness or ipseity raises the tantalizing (if contentious) hypothesis that the neural correlates of such a state would bring us closer to understanding what we mean by consciousness from a neuroscientific perspective.

Our decision to focus on long-term Buddhist practitioners, however, should not diminish the importance of future research on novices, of longitudinal studies of changes over time in novice or mid-range practitioners, or of research involving other contemplative traditions. This point is crucial if one believes that some of these meditative practices have the potential to evolve into a more secular form of mental training, with alleged therapeutic, pedagogical, and/or health value. Most importantly, the collective evidence showcased in this review underscores the fact that many of our core mental processes, such as awareness and attention and emotion regulation, including our very capacity for happiness and compassion, should best be conceptualized as trainable skills. The meditative traditions provide a compelling example of strategies and techniques that have evolved over time to enhance and optimize human potential and well-being. The neuroscientific study of these traditions is still in its infancy, but the early findings promise both to reveal the mechanisms by which such training may exert its effects and underscore the plasticity of the brain circuits that underlie complex mental functions. It is our fervent hope that this review will stimulate additional research and will lead to the increased use of these practices in a wide range of everyday contexts.

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Notes

1. Number of articles indexing the term "meditation" in Medline in 2005.
2. For a fruitful and pragmatic development of this hypothesis see Depraz, Varela, & Vermersch (2003).
3. To facilitate further inquiry by readers unfamiliar with the relevant Asian languages, only sources available in English have been used to present the pertinent Buddhist theories and practices. It is important to note, however, that many of the most relevant Tibetan texts in particular have yet to be translated reliably into any European language.
4. Gethin (1998) provides an excellent overview of the *Abhidharma* and its context. It is important to note that the two classical South Asian languages most relevant to the history of living Buddhist traditions are Sanskrit and Pāli. Sanskrit is relevant especially to Tibetan, Chinese, Japanese, and Korean Buddhism. Pāli is still a scholarly language of the Theravāda Buddhist traditions that are active especially in Śrī Laṅka, Thailand, and Myanmar. For consistency, we have used Sanskrit for technical terms that apply generally to Buddhist traditions, but some academic sources will favor the Pāli equivalents. In such sources, *Abhidharma* would be rendered as *Abhidhamma*.
5. In English, the term "lovingkindness" is often used in lieu of "compassion" because it more accurately translates the Sanskrit compund, *maitrīkaruṇā*. This compound consists of two terms: *maitrī*, translated as "loving," is defined as the aspiration for another to be happy, and *karuṇā*, translated as "kindness," is defined as the aspiration that another be free of suffering. The term *karuṇā* is also translated as "compassion," and in Tibetan it is rendered as *snying rje*, the term that occurs in "nonreferential compassion" *(dmigs med snying rje*; Skt., *niralambanakaruṇā)*. Nevertheless, even though the most accurate translation of this compound should include only the word "compassion," the actual practice of generating this state involves both love and compassion; that is, both maitrī and karuṇā.

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