

Chapter 27 Meditation and Neuroscience: From Basic Research to Clinical Practice

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Meditation has been extensively practiced in many civilizations for thousands of years as a means of cultivating a state of well-being and for religious purposes. It has now started to be studied in terms of its influence on the brain and body and used in clinical settings. This chapter will first review meditation effects at the physiological, attentional, and affective levels and the scientific paradigms used to study these effects. A clinical application on emotion regulation will then be presented.

Spiritual practices that aim at transcending the common state of consciousness can be found in human societies all over the world down to shamanic practices in the Paleolithic (Walter & Neumann Fridman, 2004; Winkelmann, 2000). Formal references to meditation can be found in ancient texts as early as the third century BCE in the Buddhist writings of the Abhidharma (Cox, 2004). Today, "meditation" is used as a generic term to refer to a wide range of practices for self-regulation of emotion and attention (Gunaratana, 2002) and is considered an inherently experiential practice present in most religious or philosophical traditions. Meditation generally involves focusing one's attention on a particular physical or mental object. When mind wandering occurs, practitioners are instructed to bring their attention back to the meditative task. Meditation practices often involve altered states of consciousness although these typically only arise during intensive practices of several hours a day. Meditation practitioners often perform daily meditation for a period of time ranging from 15 minutes to several hours, with the goal of getting insight into the nature of their minds and the universe or reaching a state beyond the materialistic world and connecting with the infinite (or a divinity, depending on the meditation tradition).

Based on the assumption that different conscious states are accompanied by different neurophysiological states, a neuroscientific approach to meditation focuses on altered sensory, cognitive, and self-awareness experiences. Meditation-induced neurophysiological changes may be of two kinds. Changes that occur during meditation practice are referred as state changes. Changes which build up over months or years and persist even when the mind is not actively engaged in meditation are referred to as trait changes (Cahn & Polich, 2006). . On one hand, the study of meditation states is especially relevant for consciousness

research as a means of exploring the effect of meditation itself on the brain. On the other hand, the study of meditation traits is more particularly adapted to the study of meditation's beneficial effects on health and general well-being in association with potential clinical applications.

There are a large number of distinct meditative practices, but given that self-regulation of attention is a major component that is common among all of them, it is possible to classify meditative style on a continuum, depending on how attentional processes are directed (Cahn & Polich, 2006). Lutz, Slagter, Dunne, and Davidson (2008) proposed a theoretical framework in which meditation practices are categorized in two main groups. Concentrative—or focused attention—techniques involve continuous sustained attention on a selected object: the object of focus may be breath or body sensations, a subvocal repeated sound or word (mantra), or an imagined mental image. Focused attention meditation requires the narrowing of awareness so that the mind only contains the object of focus. On the other hand, mindfulness meditation practices, also called open-monitoring or insight meditation, involve the expanding of awareness with no explicit focus (except awareness itself). In mindfulness, practitioners are instructed to allow any thought, feeling, or sensation to arise in consciousness while maintaining a nonreactive awareness to what is being experienced. Mindfulness may be described as sustained awareness aimed at nonreactive and nonattached mental observation, without cognitive or emotional interpretation of the unfolding moment-to-moment experience (Cahn & Polich, 2006; Gunaratana, 2002; Kabat-Zinn, 2003; Lutz, Slagter, et al., 2008).

Different Types of Meditation

Meditation traditions exist all over the world. A lengthy and exhaustive review would be necessary to attempt to describe each and every one of them, so this chapter will focus on only a few of them, mostly from Asian traditions, since these are the traditions that have been studied the most by Western scientists.

Soto Zen is a tradition based on mindfulness and open awareness. One practices it while sitting, usually facing a wall with open eyes. Practitioners are instructed to observe their thoughts and emotions as they arise in their minds and not to cling to them or engage in narrative thinking but simply let these thoughts or emotions go and remain purely aware of sitting. Every time practitioners realize that the mind has started to wander (i.e., they identified with a thought), they have to bring their attention back to the present moment. This practice is also called Shikantaza, a Japanese term that means "nothing but precisely sitting."

In Rinzai Zen, the other major form of Zen practice, practitioners are instructed to concentrate on koans. Koans are riddles that cannot be solved with knowledge or thinking. "What is the sound of one hand clapping?" is a popular Zen

koan. Zen students are given a koan by a Zen teacher, depending on their level of development in the practice and their personality. They are then instructed to meditate on it until they can solve it. They regularly present their solution to their teacher and, if successful, are given a new koan. Koans are ways to help meditators get out of the thought-based state of ordinary consciousness and access pure awareness of the present moment.

Vipassana meditation is another meditation technique that is now widespread in the West. In Vipassana, practitioners begin by observing their breath around the area of the nostrils to help the mind develop sustained, focused attention. Every time the mind wanders, they have to bring it back to the sensation of breathing. As they do so, attention gets sharper and sharper. Then practitioners have to mentally scan sequentially and meticulously each part of the body and feel the sensation in each of these body parts. They continuously keep their attention moving down from head to toes and then up in the reverse direction. At first, they find it hard to experience sensation in each and every part of the body, but with practice, they progressively come to feel sensations in more parts of their bodies. Participants are only instructed to keep their attention moving and observe, objectively and with equanimity, the sensations that they are experiencing. Practitioners should try to avoid developing feelings of aversion or cravings for specific sensations, as this is believed to disturb both body and mind. Vipassana is a good example of a meditation practice in which focused attention and open monitoring are both incorporated.

Mantra or prayer meditation might be the most popular type of meditation worldwide and is present in Tibetan Buddhism, Sufism, Hinduism, and many other traditions. It became widespread in the West in the 1960s with the development of transcendental meditation (TM). A mantra is a religious or mystical sound, word, or poem that can be either recited aloud or subvocally. For instance, Hare Krishna practitioners are instructed to repeat the 16-word Hare Krishna mantra, "Hare Krishna Hare Krishna, Krishna Krishna Hare Hare, Hare Rama Hare Rama, Rama Rama Hare Hare," 1,728 times a day, keeping the correct count with the help of prayer beads. The particular body vibration that a mantra induces is believed to calm and focus the mind and body without the need for intense concentrative efforts. When meditators repeat the mantra, they are instructed to focus their full attention on the recitation, and also sometimes on its meaning if it has one. Some practices involve mantra repetition with awareness of the breath (and others without breath awareness). As with other types of meditation, when meditators experience mind-wandering episodes, they are simply instructed to bring their attention back to the mantra.

Mantra meditation is in many ways similar to slow reading or chanting of sacred texts while one absorbs their meaning. These practices are present in all religions and spiritual traditions. Texts involved may be sutras in Buddhism (discourse from the Buddha). Christian practices,

for instance, involve recitation of a prayer phrase or the study of Scripture, which involves the slow reading of the Bible as the reader considers the meaning of each verse, and is practiced by monks of various orders. Although these practices are usually not specifically referred to as meditation, they involve focused attention and going beyond dialectic thinking, two traits they share with meditation.

Other forms of meditation may involve generating and focusing on feelings of loving-kindness or compassion toward all living beings (one of many Tibetan Buddhism practices). Mental visualization and careful examination of sacred objects is another common meditation practice in Tibetan Buddhism. Different practices can also be done while one is moving. In the case of walking meditation, one has to walk slowly, keeping breath coordinated with each step, and remain aware of every body sensation and movement. While working or doing simple tasks, one may simply be present and focused on the action being done now, that is, giving the present moment one's undivided attention, without thinking about past or future events. Walking and work meditation are an important part of Zen practice. Yoga is also a form of meditation in movement. It combines specific physical postures, breath patterns, and body awareness.

In most meditation traditions, daily practice is supplemented by retreats that involve intensive practice. These retreats are often held in complete silence. They can last from a few days to several months or even years. In the Tibetan meditation tradition, for instance, it is not uncommon to see dedicated practitioners engage in monastic life spending several years of their lives in complete silent isolation.

Finally, practices have been adapted for clinical use based on traditional forms of meditation. An example is Jon Kabat-Zinn's mindfulness-based stress reduction program (Kabat-Zinn et al., 1992). This program involves a daily meditation practice and is usually taught in 2-hour weekly classes over a period of 8 weeks, including a full day of meditation.

History of the Scientific Study of Meditation

Meditation has been the subject of scientific research for about the past 40 years but only started to gain popularity in the late 1990s (figure 27.1). The neuroscientific study of meditation has involved both fundamental and clinical research and aims at understanding how mental training affects the brain, the body, and overall health. In fundamental research, experience-induced changes in brain activity and anatomy, that is neuroplasticity, are a major focus of study (Bourgeois, 2005; Draganski, Gaser, Busch, Schuierer, Bogdahn, & May, 2004). Interestingly recent results suggest that meditation, which is a purely mental activity, may also induce brain plasticity (Lutz, Greischar, Rawlings, Ricard, & Davidson, 2004). As it often triggers

altered states of consciousness, meditation also holds an important place in the experimental framework of consciousness research (Lutz, Dunne, & Davidson, 2007; Thompson, 2006; Varela, Thompson, & Rosch, 1999). Both of these fields have benefited from the development of brain-imaging techniques (fMRI, PET, EEG, MEG) and progress in signal analysis (Friston, 2002; Lachaux, Rodriguez, Martinerie, & Varela, 1999; Makeig, Debener, Onton, & Delorme, 2004). These technological improvements allow for a better characterization of dynamical interactions in the brain and thus enable scientists to study problems that have long been relegated to the realm of philosophy, such as the question of consciousness. These recent developments, together with the development of medical practices incorporating meditation in therapeutic protocols—and thus the need to validate meditation's impact on the brain and body—account for the recent popularity of meditation studies in neuroscience research.

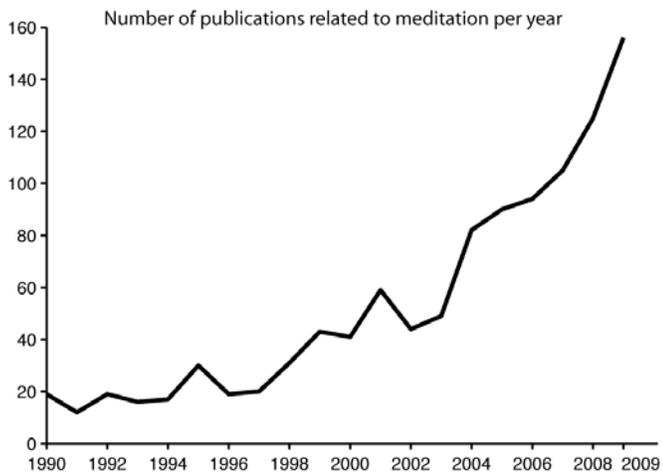


Figure 1. Search results for the term “meditation” from PubMed, 1990–2009

Scientific interest in meditation also reflect a recent shift in cognitive science toward viewing the integration of consciousness and first-person experience as a valuable object of scientific investigation. At the end of the 19th century, the importance of subjectivity and introspection were emphasized both in philosophy by Husserl (1936/1970) and in the scientific study of mental phenomena by William James (1890/1983). However, during the following decades, science attempted to reduce cognition and all mental phenomena to their observable consequences in the world. In the first part of the 20th century, behaviorists praised the study of the mind in examining behavioral performances and electrophysiological responses. Behaviorism led to a complete rejection of subjectivity and private experience, which were judged to be outside of the field of science. The development of cybernetics around 1940–1950 and the subsequent birth of cognitive science led scientists to regard the brain as an information-processing unit, and the

architecture of the first computers was used as a model for the brain. Even though the work of Gestalt psychologists (Koffka & Schoen, 1955) and phenomenological philosophers such as Merleau-Ponty (1995) attempted to develop more subjective approaches to the mind, the reductionist approach to cognition has had a lasting influence on cognitive science. In the last two decades, the development of embodied and situated approaches to the mind has encouraged reconsideration of the body's role as well as first-person experience in cognition. These approaches view cognition as arising from the coupled interactions of the brain, body, and environment (Damasio, 1994; Varela et al., 1991). This shift has been accompanied by the renewed use of subjective data in experimental protocols (Jack & Roepstorff, 2003; Varela & Shear, 1999). Coming from the embodied cognition perspective, which sees first-person experience as critical to a complete understanding of the mind, Varela developed the neurophenomenology approach, which combines first-person report of subjective experience with experimental study of brain activity (Lutz et al., 2007; Thompson, 2006).

The neurophenomenology approach to meditation has been successfully applied in experimental studies of visual perception (Lutz, Lachaux, Martinerie, & Varela, 2002), in which subjects were extensively trained to report their subjective experience during a psychophysical visual task. For meditation to be integrated into experimental studies, neurophenomenology needs precise and reliable subjective descriptions of the mind during the meditative state. The neurophenomenology approach to meditation was adapted from Buddhist meditative psychology concepts (Lutz et al., 2004; Raffone et al., 2007; Varela et al., 1991). Buddhist meditative traditions, like many others, are based on mental training of capacities for sustained, attentive awareness of the moment-to-moment flow of experience, a practice that is supposed to allow the practitioner to develop deep insight into the nature and functioning of the mind and consciousness (Dreyfus & Thompson, 2006; Gunaratana, 2002). The basis of Buddhist meditative psychology is directly based on reports from expert meditators and is supposed to be empirically testable. While still in its infancy, neurophenomenology will certainly help us understand consciousness and bridge the gap between brain neural dynamics and subjective human experience (Rudrauf, Lutz, Cosmelli, Lachaux, & Le Van Quyen, 2003; Thompson, 2006; Varela et al., 1991).

Meditation and the Peripheral Nervous System

Since meditation is often considered to be a relaxation technique, it is reasonable to assume that meditation practice affects the functioning of the body. The mechanisms underlying the effect of meditation on the body are not yet understood, and as for cognitive and brain activity correlates of meditation, we currently lack formal

evaluation procedures for the diverse meditation types and methodologies being used (Cahn & Polich, 2006). We will thus only provide a brief overview of interesting research directions.

Body Representation

Meditation induces long-lasting changes to one's body perception that can be observed both at low-level cortical representations and at higher-level representation associated with the sense of self (Cahn & Polich, 2006).

Meditation-induced changes in cortical areas devoted to process inputs from the body are reported by Lazar et al. (2005) and could account for increased awareness of the sensory field. Lazar et al.'s study shows that regular practice of open-monitoring meditation—which focuses on both internal and external sensations—increases the thickness of the cortex in somatosensory areas of the brain. This increase in cortex thickness was positively correlated with meditation experience, so we may hypothesize that it functionally corresponds to an increase in body awareness. Testing this hypothesis, Khalsa, Rudrauf, Damasio, Davidson, Lutz, and Tranel (2008) had long-term meditators in both active (yoga) and sitting forms of meditation and non-meditators perform a heartbeat detection task in which participants had to tell whether or not short sounds were displayed synchronously to their own heartbeats (they had to try to feel their heartbeats without using their finger on peripheral arteries). He found that the meditators did not perform any better than the non-meditators. This suggests that changes in meditators' body representation are not functionally correlated with better perception of physiological sensation. However, in this study, meditators systematically rated their experience of interoceptive perception higher than did control subjects. Collection of their subjective experiences also revealed that they found the heartbeat-counting task to be easier than non-meditators did. Lazar et al.'s results might then directly index improved body awareness without improved body representation.

Meditation practice also induces changes in one's representation of the self. An fMRI study by Farb et al. (2007) showed a decreased coupling between the insular cortex, which is involved in the perception of pain and internal body responses, and the medial prefrontal cortex (mPFC), which is involved in higher-level cognition, after an 8-week open-monitoring meditation program. This suggests the presence of a different type of self-awareness in meditation practitioners that is less rooted in one's sense of body and more oriented toward an "impersonal beingness" (Cahn & Polich, 2006).

Effect of Meditation on the Autonomic and Immune System

Meditation affects bodily functions in two different ways: standard daily meditation practice creates a low arousal state, and peak meditation experience fosters a high arousal state. According to early theoretical models, infrequent peak experiences have quite a different high

arousal tone than the more common meditative states (Cahn & Polich, 2006), but it is difficult to study such experiences because of their rarity. This section will thus only review data concerning the usual trait commonly experienced during meditation practice. Based on early studies of transcendental meditation, Jevning, Wallace, and Beidebach (1992) qualify the common meditation state as a "wakeful hypometabolic state."

The autonomic nervous system controls the activity of organs and viscera in the body. It is composed of the sympathetic and parasympathetic neural pathways. Although this is a schematic view and the reality is far more complex, these two components are usually believed to have opposite actions on their targeted organs or tissues. The sympathetic system is most often involved in energy mobilization, preparing the organism to react (flight-or-fight response, response to stress), whereas the parasympathetic component is responsible for most resting and restoration functions (rest and digestive functions) of the organism (Jänig, 2003).

One possible way for meditation to act on autonomic activity is through respiration control. Respiration is one of the body's few autonomic functions that can be controlled and can affect functioning of the autonomic nervous system (Badra et al., 2001; Eckberg, Nerhed, & Wallin, 1985). Many meditation traditions consider breath, body, and mind to be linked and thus have given, whether explicitly or not, the breath a central role in meditation practice. Voluntary control of the breath may be achieved through specific inhalation-exhalation rhythmic patterns, as in pranayamic practice and the slow diaphragmatic breathing practiced in yoga that involves specific movement of the thoracic cage. Breath also tends to involuntarily slow down during mantra chanting (Bernardi et al., 2001), breath-counting meditation, and simple awareness of the breath (Lehrer, Sasaki, & Saito, 1999).

Slower respiration rate during meditation practice induces changes in cardiovascular activity that correspond to an increase in the activity of the restorative parasympathetic system (Saul, 1990). This increased parasympathetic activity has also been assessed through the slowing down of basal heart rate in meditators (Pal, Velkumary, & Madanmohan, 2004) and the increased synchronization, or respiratory sinus arrhythmia (RSA), between the breathing cycle and the heartbeat during meditation (Cysarz & Bussing, 2005; Ditto, Eclache, & Goldman, 2006). RSA corresponds to high variability in heart rate as heart rate becomes faster during inhalation and slower during exhalation. Mechanisms behind human RSA are not yet well understood (Grossman & Taylor, 2007; Tzeng, Sin, & Galletly, 2009) but might be important to meditation research, as RSA could be used as an index of successful emotion exposure during meditation (see the section on emotion, below).

Slow breathing has also been associated with increased baroreflex sensitivity (Joseph, Casucci, Casiraghi, Maffei, Rossi, & Bernardi, 2005; Reyes del Paso, et al., 2006). Decreased blood pressure is often reported after

meditation practice by both healthy individuals and hypertension patients (Carlson, Speca, Faris, & Patel, 2007; Manikonda et al., 2008). Improved control of blood pressure is usually considered a sign of balance between parasympathetic and sympathetic activity. Finally, since one role of sleep is to restore the balance in these autonomic systems, the fact that meditators typically require less sleep than control subjects (Ajaya, 1976) suggests a better balance between these two systems.

Although few studies have been conducted, there is increasing evidence that meditative practice also affects the immune system. Psychological states such as stress affect the functioning of the immune system (Segerstrom & Miller, 2004). The immune system is indirectly under the influence of the central nervous system via hormonal signaling and through activity of the autonomic nervous system (Dantzer & Kelley, 1989; Jänig, 2003). Davidson et al. (2003) found faster peak rise for the antibody response to a flu shot among healthy meditators who underwent an 8-week mindfulness-based stress reduction (MBSR) training course in open-monitoring meditation than among non-meditators. Increased number and increased activity of lymphocyte T and other natural killer cells have also been found in HIV patients after MBSR training (Robinson, Mathews, & Witek-Janusek, 2003; Taylor, 1995). Finally, in a recent study, Pace et al. (2009) assessed the effect of compassion meditation (in which one works at developing altruistic emotions and behaviors towards all living beings) on the immune response and found a negative correlation between the amount of meditation practice and induced stress immune response.

We should develop a better understanding of meditation effects on the autonomic and immune systems as we improve our understanding of these systems' relationship and their dynamic links to the central nervous system. Study of slow oscillatory activity in both the central and autonomic systems would likely shed light on coupling mechanisms between the brain, vegetative functions, and the mind (Basar, 2008). Jerath, Edry, Barnes, and Jerath (2006) built a model of synchronization between the cardiopulmonary and the central nervous systems to explain how slow, deep pranayamic breathing practiced in yogic meditation can influence the autonomic nervous system. Davidson et al. (2003) also found that left-sided anterior oscillatory activity of the brain is positively correlated with activity of the immune system after meditation practice, assessing through the quantity of natural killer cells. This type of hemispheric activity has also been correlated with both the autonomic system activity and emotional regulation (Craig, 2005), as we will see in the section dealing with emotions. Thus, although a growing body of evidence showing a link between mind and body states has accumulated over the years, more research will be needed to unravel the mechanisms underlying the effects of meditation on the autonomic and immune systems.

Meditation and Aging

As we have seen, meditation training seems to protect against stress and boosts the immune system. It has also recently been shown to reduce neuronal decay due to normal aging. Pagnoni and Cekic (2007) found greater prefrontal cortex thickness in middle-aged meditators than in non-meditators, as well as a decline in cortical thickness associated with age, a result that is also reported by Lazar et al. (2005). Nagendra, Sulekha, Tubaki, and Kutty (2008) also showed that expert Vipassana meditators did not present sleep patterns associated with aging. Both the length of the slow waves sleep period before the occurrence of the first REM sleep episode and the total length of REM episodes typically decrease with age. They showed that this decrease was drastically smaller in meditators of age 50–60 than in control subjects of the same age. This suggests that meditation slows down the brain-aging process through a mechanism that has yet to be discovered.

Meditation and Attention

The cognitive function that meditation may affect the most is attention, since meditation is a form of attention training. Meditation is a skill and as such it may train attentional systems. As physical training strengthens body muscles, mental training involved in meditation reinforces brain attentional circuits. Meditation recruits attentional brain areas involved in learning. Using fMRI, a technique that monitors metabolic activity in the brain as reflected by variations in blood flow, Brefczynski-Lewis, Lutz, Schaefer, Levinson, and Davidson (2007) found that in a group of Tibetan Buddhist meditators, focused attention meditation is associated with greater activation in multiple attention-related brain regions (dorsolateral prefrontal cortex, superior frontal sulcus, and intraparietal sulcus). Interestingly, brain activation varied based on the person's level of expertise. Expert meditators had less activity in attention-related brain regions, whereas greater activity among less expert meditators was associated with skill acquisition. This reduced metabolic activity in attention-related regions of highly expert practitioners suggests an effortless—though efficient—strategy for attentional resources allocation. This is supported by traditional Buddhist descriptions of a decreased need for voluntary attentional effort to attain concentration for expert practitioners. Using electroencephalography, Lutz et al. (2004) also found that brain activity varies based on expertise. These results suggest that meditation is a technique that is learned and perfected over years of practice.

According to Lutz, Slagter, et al. (2008), meditation practices involve at least three attention regulation subsystems. First, meditation may involve intense object-based concentration. Selective attention—or orienting—is the selection of specific information from the flow of sensory input and involves cortical structures known to gate information, such as the temporal-parietal junction, the

ventrolateral prefrontal cortex, the frontal eye field, and the intraparietal sulcus (Corbetta & Shulman, 2002). Second, meditation imposes continuous monitoring of the focus of attention. Sustained attention—or alertness—is the maintenance of a state of high sensitivity to a perceived stimulus or mental object over time and most likely involves sustained synchronous activity between the thalamus and the right frontal and right parietal cortical structures—also known as the thalamo-cortical loop (Berger, Kofman, Livneh, & Henik, 2007; Coull, 1998; Posner & Rothbart, 2007). Finally, meditation also involves transient attention shifts, as when one disengages attention from a source of distraction and redirects it to the intended object of concentration (Cahn & Polich, 2006; Lutz, Slagter, et al., 2008). This involves executive attention—or conflict monitoring—which is the monitoring and resolution of conflicts among thoughts, feelings, and mental plan. This function is managed by the dorsal anterior cingulate cortex and the dorsolateral prefrontal cortex, structures that have also been shown to be activated when one is self-conscious (Ridderinkhof, Van Den Wildenberg, Segalowitz, & Carter, 2004; Weissman, Roberts, Visscher, & Woldorff, 2006).

Meditation Improves Perceptual Attention Capacity

Perceptual pre-attentive processes are sometimes under voluntary control—as, for instance, when we focus our attention on an object or sound—although they may also be affected by environmental cues. Selective visual attention focused on an object may be involuntarily influenced by the surrounding objects; for example, distracting visual stimuli of high contrast have been shown to automatically redirect this type of attention (Friedman-Hill, Robertson, Desimone, & Ungerleider, 2003). Below, we show how meditation affects involuntary allocation of low-level attentional resources.

In the auditory domain, pre-attentive processes involve the automatic detection of environmental changes and can be studied in the laboratory through the brain's electrical response (event-related potential) to a flow of frequent auditory stimuli interspaced with infrequent ones. The amplitude of the differential electrical activity between frequent and infrequent stimuli, called mismatch negativity, was found to increase immediately among expert practitioners after a focused attention meditation session (Srinivasan & Baijal, 2007). Similar findings were found for Vipassana meditation (Cahn, 2007). Focused attention training and the higher degree of awareness of the body and sensations induced by meditation might be responsible for increased sensory cortex sensibility. According to one interpretation, neuronal populations tuned to different stimuli inhibit each other and compete for attentional resources (Näätänen, 1992). Neuronal populations tuned to properties of the standard stimulation respond less vigorously upon repeated stimulation and become desensitized. Thus when a deviant activates a distinct new neuronal population, these fresh afferents respond more vigorously, eliciting mismatch

negativity. Meditation would make these perceptual systems sharper and more sensitive.

Experimental work also shows that open-monitoring meditation increases processing capacity in the visual system. This evidence comes from a study using the attentional blink paradigm. In this paradigm, two stimuli are presented in close succession. As a result of allocation of all attention resources to the first stimulus, the second one is often not perceived. However, both behavioral and event-related potential results show that intensive 3-month open-monitoring retreats decrease the attentional engagement in processing the first target, thus allowing subjects to process and perceive the second one (Slagter et al., 2007).

These results indicate that meditation tends to boost low-level attention. This could be due to increased attentional resources. Meditation could recruit new attention-dedicated neuronal networks or strengthen existing ones. Another hypothesis is that attentional resources are constant. However, since meditation tends to quiet the mind, we may observe a disengagement of attention from higher cognitive and verbal areas. If attentional systems are not dealing with thought affects, they might have more resources to deal with low-level perceptual systems.

Meditation Decreases Perceptual Habituation

Neural and perceptual systems tend to habituate to repetitive presentation of stimuli, to which early responses are larger than later ones. Meditation has been shown to decrease perceptual habituation to repetitive stimuli. This type of effect has been mostly observed in open-monitoring meditation, in which the practitioner develops attention to the present moment-to-moment experience without allowing his or her attention to wander. In this meditation, each stimulus is seen as fresh and new in the present moment. As an individual practicing open monitoring works on perceiving each experience as it arises in the moment without judging, it might cut off automatic brain mechanisms responsible for habituation, establishment of routines, and action scenarios. A classical habituation paradigm involves repetitively presenting the same stimulus and observing the decrease in the induced 10-Hz brain alpha wave amplitude with the number of stimulus presentations. Non-habituation was demonstrated with open-monitoring meditators where the electroencephalographic alpha rhythm amplitude did not decrease after repeated stimulus presentations (Deikman, 1966; Wenger & Bagchi, 1961). These findings are also consistent with Cahn's study (2008) showing less automated recruitment of frontal attentional circuits when rare and salient auditory stimuli are processed during Vipassana open-monitoring meditation practice.

Open-monitoring meditation also allows for faster reallocation of attentional resources. Valentine and Sweet (1999) used an auditory sustained attention task in which participants had to mentally count the number of beeps in several series of tones presented at different rates. In general, fast series came unexpectedly. Open-monitoring meditation

resulted in better counting performance in the unexpected fast series. Interestingly, this effect was not observed with focused attention meditation. One explanation is that practitioners of concentrative meditation might have focused intensively on the slow series and may have difficulty shifting their attention to start counting the faster series. On the other hand, open-monitoring practitioners, who only partially practice engaging their attention, could more easily shift their attention to the fast presentation rate.

These results indicate that meditation allows for non-habituation and faster reallocation of attention. Beyond low-level attention allocation, we will see now that meditation also has unexpected effects on the activity in higher perceptual areas.

Meditation Reduces Neural Population Competition in Higher Perceptual Areas

Carter, Presti, Callistemon, Ungerer, Liu, and Pettigrew (2005) reported results of a study of 23 Tibetan Buddhist monks who have been engaged in either focused attention or open-monitoring meditation. These monks were asked to perform a "binocular rivalry" task during which they were presented with two images, one before each eye. Under these circumstances, they were randomly experiencing either both images simultaneously or each of them alternatively for 2–3 seconds as the images competed for attentional resources in the visual system. No effects of open-monitoring meditation were observed either during or after the practice. However, monks practicing focused attention meditation were able to maintain a stable, superimposed percept of the two competing images for a longer than normal duration. These results suggest that selective and sustained attention allows conflicting stimuli to be perceived simultaneously by long-term expert practitioners both during and following focused attention meditation. This also points to the remarkable influence of meditation training on the brain, as no other mental training has been shown to affect allocation of attentional resources responsible for binocular rivalry.

Open-monitoring meditation also seems to allow meditators to more efficiently process stimuli competing for attentional resources. The Attention Network Test has been used to assess open-monitoring meditation influence on attentional subsystems. The test has subjects indicate the direction of a target arrow surrounded by flanker stimuli that either point in the same or reverse direction, thus inducing perceptual conflict (Fan, McCandliss, Raz, & Posner, 2002). Results show that after 5 days of open-monitoring meditation training, participants improved their performance in responding to trials with conflicting conditions (Tang et al., 2007). Both of these experiments show that meditation helps to efficiently process different conflicting stimuli.

Meditation and Higher-Level Attention for Monitoring Mind Wandering

What meditation practice brings to awareness is the presence of private thoughts and feelings that constantly pull attention away from its focus. This experience is not restricted to meditation practice. In our normal daily activities—while reading, for instance—we may suddenly notice that instead of being focused on the task at hand, we are focusing on unrelated thoughts and feelings (Schooler, Reichle, & Halpern, 2004). These attentional drifts are termed "mind-wandering episodes" (Smallwood & Schooler, 2006), during which attention transiently focuses on the flow of spontaneous thoughts, what James (1890/1983) called "the stream of consciousness." The subject is generally not aware of it when mind wandering occurs, and it is only after a certain period of time that he or she becomes aware that his or her attention has drifted. This realization is called meta-consciousness, a re-representation of conscious contents (Schooler, 2002; Smallwood, McSpadden, & Schooler, 2007). The mind-wandering phenomenon highlights two important facts: first, that the quality of focused attention is fluctuating, and, second, that we lack awareness of these fluctuations.

Practice of either focused attention or open-monitoring meditation requires one to keep track of which object attention is directed at and to bring it back to the object of focus each time it wanders away. This type of training may help someone become aware of mind-wandering episodes and help him or her stay focused on the moment-to-moment experience (Gunaratana, 2002). Mind wandering and meditation are thus two very different—if not opposite—states of consciousness. Mind wandering represents a shift in attention "away from the here and now" toward private thoughts and feelings (Smallwood, O'Connor, Sudbery, & Obonsawin, 2008), whereas the very basis of meditation is being present in "the here and now" without letting one's attention to be distracted by thoughts and feelings (Gunaratana, 2002; Lutz, Slagter, et al., 2008).

In favor of this hypothesis, Farb et al. (2007) revealed distinct fMRI neural activation patterns in control subjects with no meditation training compared to subjects who followed an 8-week open-monitoring MBSR program. Control subjects were primarily experiencing a mental narrative state, where one allows one's attention to be caught by a given train of thought, whereas meditation practitioners were aiming at experiencing moment-to-moment awareness of the self. Mental narrative led to strong activation of the mPFC, and awareness of present experiences led to decreased activation of the mPFC and increased activity in right lateral PFC and right viscerosomatic areas (Farb et al., 2007). Thus there might be two possible types of experience of the self: one—engaged during mind wandering—based on thoughts dealing with past or future experiences of the ego, and one based on the moment-to-moment experience of the self, involving awareness of sensory information from the body. This indicates that the experience of self in the present moment is dramatically different both experientially and in

terms of brain activity from the experience of self as projected in the past or the future, as in mind wandering.

Meditation, Mind Wandering, and "Default Network" Brain Activity

The concept of a default mode of brain functioning at rest emerged from the consistent deactivation of a brain area network during a series of psychophysical tasks compared to resting baseline (Greicius, Krasnow, Reiss, & Menon, 2003; Raichle, MacLeod, Snyder, Powers, Gusnard, & Shulman, 2001). The brain network involved in baseline activity includes the mPFC, the dorsal part of which has been associated with self-referential and emotional mental activity (Gusnard, Akbudak, Shulman, & Raichle, 2001; Ingvar, 1985). Recently, higher activity in the same default network was found during a task with a high occurrence of mind-wandering episodes than during a task with a low occurrence of such episodes (Mason, Norton, Van Horn, Wegner, Grafton, & Macrae, 2007), which suggests that mind wandering could be the main underlying experience of the brain default network. For non-expert meditators, practicing meditation with attention focused on a particular object brings to awareness how frequent and pervasive mind-wandering events are. Sonuga-Barke and Castellanos (2007) proposed a hypothesis to explain the presence of mind-wandering events. Fluctuation in the quality of sustained attention, (i.e., the occurrence of mind-wandering events while one is focusing on a task) could be in part due to interference with the default mode of brain activity. In this model, interoceptive and exteroceptive attentional focus are slowly but continuously fluctuating at rest, so as to allow individuals to perceive the environment and process it cognitively. Engagement in a task (exteroceptive attention) first attenuates interoceptive attention, although with time, activity in interoceptive attention network components gradually returns, leading to episodes of mind wandering. Long-term effects of meditation training could be enhanced capacity to inhibit introspective spontaneous activity during sustained attention engagements through modification of large-scale neuronal network connectivity and activity (Lutz et al., 2008).

Consistent with this hypothesis, electroencephalography shows spontaneous fluctuations between two distinct and supposedly opposite modes during resting-state brain activity (Laufs et al., 2006). One of these modes is characterized by the presence of slow oscillations of 3–7 Hz (theta activity), which are associated with reduced level of vigilance. The other mode is characterized by the presence of fast oscillations of 12–30 Hz, which are usually associated with high vigilance levels. These spontaneous patterns of increased and decreased theta activity have recently been associated with periods of mind wandering and periods of concentration, respectively (Braboszcz & Delorme, 2009; Cahn, 2007). The hypothesized association between different vigilance levels and mind-wandering and meditation is also supported by EEG studies based on event-

related potential analysis. These studies reveal that mind wandering is associated with a reduced capacity for processing external events, as assessed by a decrease in amplitude of the brain's electrical response in this state (Smallwood et al., 2008), whereas meditation is associated with increased sensory information processing (Cahn & Polich, 2009; Srinivasan & Bajjal, 2007). Thus, mind wandering tends to disconnect people from their environments, whereas meditation tends to sharpen their perceptions of it.

While meditation practice benefits psychological well-being, mental states with a high frequency of mind-wandering episode, such as depression or boredom, are experienced negatively. Carriere, Cheyne, and Smilek (2007) found that frequent brief lapses of attention, that is, lack of conscious awareness of one's action, is associated with proneness to boredom and depression among students. More frequent and intense periods of mind wandering during a word-encoding task have also been linked to dysphoria (Smallwood et al., 2008). On the other hand, an open-monitoring meditation offered to students during a month of MBSR intervention reduced their psychological distress as well as their ruminative thoughts (Jain et al., 2007).

Meditation and Emotions

Regardless of the specific meditation technique, meditation leads to state and trait experiences involving a deep sense of peace and calm. In fact, achieving enduring happiness by freeing oneself from affliction is the central doctrine of Buddhism (Ekman, Davidson, Ricard, & Wallace, 2005). The fact that meditation affects the way emotions are experienced and allows for better regulation of negative and distressing feelings is in part an outcome of meditation-induced changes on body, brain, and cognitive functioning.

Emotions may be seen as a set of interrelated changes in the body in response to a real or imagined situation or stimulus. Emotions are experienced as feelings and may interrupt ongoing behavior or mental processes in to the form of an urge to engage in action (e.g., flight for fear, outburst of anger), depending on the emotion felt (Hamm, Schupp, & Weike, 2003). Emotions elicit responses and changes both in the body and in the attentional systems. Increased processing of body sensory inputs might also affect the way emotions are first perceived through somatosensory information. Increased concentration results most likely in better control of mind wandering; that is, enhanced attention and better resistance to distraction might reduce emotional reaction by reducing negative emotions' propensity to interrupt the ongoing stream of thoughts and behavior. Changes in attentional capacities are also most likely linked to changes in brain activity, especially in the anterior areas, in which neural activity has been linked to the

functioning of the autonomic and immune systems, which are known to be affected by meditation.

The Links Between Brain, Body, and Emotion

In the last 20 years, asymmetries in brain electrical activation have been linked with the way people react to emotional situations and regulate their emotions (Allen & Kline, 2004; Wheeler, Davidson, & Tomarken, 1993). In individuals who tend to react positively and let go quickly of negative emotions, the baseline electrical activity of the brain exhibits greater left-sided anterior activation than recordings of individuals who are more prone to nourishing negative emotions (for a review, see Davidson, 2004). After 6 months' practice of mindfulness and MBSR meditation, healthy participants showed enhanced left-sided prefrontal electrical activity in the alpha band after induction of both positive and negative feelings (Davidson et al., 2003). The same study found increased left-sided PFC activity to be associated with reduced anxiety and negative affect as well as increased experiences of positive affect. These results correlate with previous ones demonstrating that people with more left-sided baseline activation in the PFC have a more positive outlook on life than individuals with right-sided PFC activation (Davidson, 2000).

The relationship between positive affect and anterior brain areas activity is strongly supported, as reviewed by Craig (2005), by the anatomical connectivity between the autonomic system and anterior brain areas. Craig demonstrates clearly how the left anterior part of the brain interacts more directly with the parasympathetic system and the right anterior part interacts more directly with the sympathetic system. Activity in either of the hemispheres is thus associated with behavior and emotions in accordance with the opposite actions of these two components of the autonomous nervous system. Thus left-sided activation would correspond to more enriching emotions, that is, those eliciting positive, group-oriented behaviors, whereas right-sided activity would imply activity of the sympathetic system and thus reactions associated with negative, aversive behaviors.

Meditation and the Regulation of Emotions

During most meditation practice, practitioners are encouraged to keep a balanced, nonjudgmental state of mind. Practitioners can achieved this by experiencing feelings arising in their mind, then stay for a period of time, and later pass away. While meditating, practitioners in most meditation traditions are instructed to keep a calm, balanced mind, noticing affects with no feeling of aversion toward unpleasant emotions or feelings of desire for pleasant, enjoyable ones.

Contemporary research on emotion outlines two means through which emotion regulation may be achieved: attentional control and cognitive control (Ochsner & Gross, 2005). Attentional control involves manipulating the amount

of attention that is naturally allocated to process emotional stimuli. Exercising cognitive control involves changing expectations or judgments about emotional stimuli. Both of these strategies are supposedly present in meditation, whether attention is focused away from the emotion (such as in concentrative practices) or the emotion is simply being observed (such as in contemplative mindfulness practices). Cognitive control is also achieved indirectly: as meditators gain insight into their minds and bodies, their appraisal of emotion automatically evolves. In addition, meditation may also change emotion's appraisal by changing the practitioner's beliefs about the world.

The way meditation modulates pain perception may provide a good overview of how meditation affects the process through which emotions give rise to specific feeling. Pain is defined as an "unpleasant sensory and emotional experience associated with actual or potential tissue damage, or described in terms of such damage" (International Association for the Study of Pain, 1994). Recently, pain has been described in terms of a homeostatic emotion, that is, as a feeling from the body (like thirst or hunger) that elicits a specific behavior to preserve body equilibrium (Craig, 2003).

Numbness and pain that arise from long periods of sitting without moving is a common side effect of meditation practice during retreats. Constantly changing position whenever pain arises would disturb meditation, so meditators are asked to use different strategies to cope with pain. According to Gunaratana (2001), it is best to adopt a voluntary and focused attitude of simply watching the pain—that is, experiencing the pain without identifying with it. Practitioners may also try to lessen the importance of the pain by comparing it with the pain that one experienced previously in one's own life, or pain that others are experiencing. Another strategy would be to divert the attention toward another object, such as the breath, and as a last resort to slowly stretch the muscles to see if the pain can be lessened. It is said that with practice, it takes more time for pain to arise and that it becomes less intense. This resistance to pain, which is a major component of meditation retreats, probably helps meditation practitioners cope with their own suffering in a more detached way after the retreat is over.

Treatments of chronic pain based on diverse meditation practices, such as MBSR programs (Kabat-Zinn, Lipworth, & Burney, 1985; Morone, Greco, & Weiner, 2008) and loving-kindness meditation (Carson et al., 2005), have revealed positive outcomes associated with improvement of overall quality of life. Enhanced tolerance of acute pain has also been assessed in different studies with both focused attention and open-monitoring meditation. Longitudinal study of transcendental meditation shows decreased brain activation in the thalamus, prefrontal cortex, and anterior cingulate cortex in response to acute pain (immersion of the hand in hot water) after 5 months of TM daily practice in participants who were new to meditation

(Orme-Johnson, Schneider, Son, Nidich, & Cho, 2006). This study further suggests that TM practice does not change actual pain sensations (as pain rating didn't change pre- or post-TM practice and never significantly differed between beginners and long-term practitioners) but does reduce emotional distress associated with pain, resulting in enhanced tolerance of acute pain. Results of this last study are of particular significance, as they highlight meditation's effects on the regulation of the distress associated with painful feelings. Thus meditation practice changed the way individuals reacted to the emotion related to pain. In fact, meditation seems to be acting at the feeling level, in the way pain sensations are experienced subjectively as emotions. One hypothesis is that meditation training that involves developing a nonjudgmental attitude leads to change in emotion representation, resulting in less body and mental disturbance.

In fact, the different forms of self-consciousness experienced during meditation (Farb et al., 2007) and the emphasis placed on equanimity and body sensations suggest that meditation leads to a different appraisal of somatic markers than the common normal state. According to the somatic marker hypothesis of Damasio (1994), emotions mark our experiences in terms of body representation, and these somatic markers are then used to evaluate new situations and experiences. Feelings are based on bodily response and precede emotions, which are viewed as mental reactions to feelings. In this framework, keeping a nonjudgmental state of mind during meditation could delay or attenuate emotional reactions to feelings.

Meditation and Brain Imaging

The regulation of emotions, especially of negative ones, has been extensively studied using brain-imaging techniques. Studies show that meditation actually affects two important areas of the brain emotion circuitry: the amygdala and the PFC. The amygdala is engaged in producing autonomic, endocrine, and somatic responses as well as directing attention toward affective stimuli that are potentially important, such as potential threats or potential sources of food (Davis & Whalen, 2001). The PFC down-regulates neural activity in the amygdala and the two areas share reciprocal connections (Banks, Eddy, Angstadt, Nathan, & Phan, 2007; Davidson, 2002). Less body arousal and EEG brain activation has been observed in response to negative affects for yoga practitioners (Aftanas & Golosheykin, 2005). Consistent with this, when one is engaged in focused attention meditation, fMRI studies show that amygdala activity in response to emotional negative or positive sounds is decreased in long-term Tibetan expert practitioners compared to novice ones. Interestingly, the more hours participants have spent meditating in their lifetimes, the more important is the decrease in amygdala activity (Brefczynski-Lewis et al., 2007). However, fMRI studies show that when engaged in focused compassion meditation, expert meditators from the same tradition

exhibited greater amygdala activation in response to emotional stimuli than novice practitioners (Lutz, Brefczynski-Lewis, Johnstone, & Davidson, 2008).

These seemingly opposite results suggest that meditation allows for a wider range of emotional experiences, and that these experiences can be modulated through the practice of specific meditation techniques. Greater embodiment or disembodiment of emotions can be achieved through voluntarily modulation of dedicated attentional circuits that have been intensively trained through meditation practice. Consistent with this hypothesis, subjective reports indicate that meditation seems at first to intensify the experience of positive as well as negative feelings. Then through practice, these intense feelings are accepted and might contribute to the experience of a richer internal life, as reported by meditation practitioners.

Taken together, brain-imaging results support the empirical hypothesis of meditation-induced emotion regulation and suggest that it involves brain plasticity. The regular practice of meditation affects the connections between the emotional limbic system and the neocortex in such a way that it would change the individual's thoughts about and interpretation of negative emotions (i.e., his appraisal of his emotion).

Clinical Application of Meditation for Emotion Regulation

The beneficial effects of meditation on the appraisal of negative emotions have been observed in clinical practices. As we will see, meditation practice has been shown to reduce alexithymia—difficulty recognizing and expressing emotions associated with operative thought processes (Sifneos, 1973)—through development of emotional intelligence and insight into one's emotional functioning (Baer, Smith, et al., 2004).

Appearance and inclusion of meditation in clinical practices is coincidental with the rise of the "third wave" of psychotherapies. The third wave accords particular importance not only to emotions but also to the context of those psychological phenomena and to their functions (S. C. Hayes, 2004). The third wave rises in response to cognitive-behavioral therapy (CBT), a pure dialectic approach that has been successful placing emotions in their proper context but remains limited because of the large number of complex protocols. Today, working with emotion regulation is the core process for approaching and curing mental disorders (Barlow, Allen, & Choate, 2004; Campbell-Sills & Barlow, 2007), and we are currently observing a unification of all cognitive-behavioral therapy protocols with the inclusion of the core concept of mindfulness (Allen, McHugh, & Barlow, 2007). Emotion regulation, even the regulation of extremely intense emotions resulting from trauma (Brillon, 2006), is realized through a three-step process: first feeling the body sensation (arousal), then identifying and labeling emotions

that arise from both arousal and appraisal, and finally accepting the emotion in a nonjudgmental way. This last step of accepting one's own thoughts and cognitive traits has been developed by S. C. Hayes et al. (1999) in meditation-based acceptance and commitment therapy. Any clinical intervention should rely on theory addressing these three stages

.Here we first present the nature and function of emotions as well as a model of how they operate. We subsequently articulate our meditation intervention on this model.

The Emotion Apprehension Process: How Emotions Can Become Pathological

Simple principles about emotions must first be reviewed: emotions generate body (arousal) and thought (appraisal) responses (Frijda, 1986). Emotions may be useful for attaining a better response to a situation, even when they are negative (Hahusseau, 2006). In fact, patients with lesion in the ventro-median prefrontal cortex, the amygdala, or the insula, which are three important emotional brain areas, have difficulties with decision making (Bar-On, Tranel, et al., 2003). These lesions result in an incapacity to react appropriately to life events or in social contexts. This emotional intelligence deficit has been shown to be based in a neuronal system that is independent from the one supporting cognitive intelligence (Bar-On, Tranel, Denburg, & Bechara, 2003). Used at their best, emotions are felt, labeled, and accepted. If one step is missing in this process, emotions lose their power as a signal and become toxic for the mind and body.

The following metaphor will help us fully understand the need for each step in the emotion apprehension process and the potential danger of ignoring one of them: consider a wound in the sole of the foot that causes great pain when you walk barefoot on the sand. There are different possibilities for how to deal with this situation:

- 1 The pain is so intense that you take a high dose of analgesic. The medicine is effective and the pain disappears. For a few minutes after, you are careful not to walk on the wound. Then you forget about it and walk on the anaesthetized injured foot, worsening the depth and seriousness of the wound. This problem occurs because you have dissociated yourself from the pain and do not feel the wound anymore.
- 2 You feel the pain but haven't identified its origin. You believe it's a scratch and place a bandage on it without removing the piece of dirty broken glass lodged in the foot. The wound gets infected and worsens. This problem arises because the nature of the wound was not adequately identified.
- 3 You feel the pain and have identified its origin but feel scared. You refuse any examination by a doctor for fear that it will be too painful or you refuse to go to the hospital, arguing that you do not have time. The wound gets infected and you are immobilized for a long period

of time. This problem arises because you did not accept the wound.

The types of possible reaction we considered for a physical wound are also present for negative emotions. If one does not feel one's emotions (i.e., dissociative disorder), does not identify them (i.e., alexithymia), or does not accept them (i.e., emotion intolerance), analgesic effects can provide short-term relief, but mental and physical health are affected over the long term.

The Three Majors Emotional Disorders

Each of the three following emotional regulation disorders corresponds to an anomaly or blockage in the process of the emotion arising, developing, being experienced, and eventually vanishing. They are at the origin of most mental disorders and very often are intertwined. Taking them into account is thus of primary importance in therapeutic approaches.

Dissociative Disorder

The absorption experience, experienced by 80% of people when reading or watching a movie, and different forms of dissociative disorder as described in *DSM-IV-TR* (DSM IV, American Psychiatric Association, 2000) have common characteristics: the narrowing of both consciousness and perceptual fields. In its most spectacular form, it can result in multiple personality disorder or dissociative fugue. "Dissociation is a process where the usually integrated functions of consciousness, memory, identity or perception of the environment are spontaneously disrupted and certain mental events that are ordinarily processed together (e.g., thoughts, emotions, sensations, etc.) are isolated from one another" (American Psychiatric Association, 2000, p. 167).

Dissociative patients commonly have particular difficulty adapting to new situations and to establish daily routines such as choosing a regular schedule for eating or sleeping. They are poorly connected to their internal sensations and barely feel pain and other body sensations, such as their heartbeat or breathing. Dissociative patients don't adapt to day-to-day reality; they don't pay attention to directions when going from one place to another and listen to but don't comprehend conversations. There are people and objects in their homes that they know or have seen but don't remember. In general, they have few memories, even of important life events, and they doubt the veracity of those memories they do have. These persons live exclusively in the mind; they do not have feeling of themselves and are unable to focus on the present moment. If placed on a continuum, dissociative disorder and mindfulness would be at opposite ends, mindfulness being the capacity to be aware of the moment-to-moment unfolding experience while keeping a nonjudgmental attitude (Kabat-Zinn, 2004).

Dissociative disorder affects about 10% of the population (Foote, Smolin, Kaplan, & Legatt, & Lipschitz, 2006; Ross, 1991). Dissociative disorder is often associated

with difficulties controlling impulsivity, chronic pain syndrome, and fibromyalgia. It is also preponderant in patients suffering from mental disorders such as depression, anxiety disorder, addiction, anorexia, and binge eating (Valdiserri & Kihlstrom, 1995) as well as personality disorders. The most frequently associated comorbidities include borderline personality disorder and post-traumatic stress disorder (Dell, 1998).

Alexithymia

Difficulty identifying emotion, which is characteristic of alexithymia, comes from the inability to express emotions to others (Taylor, 1984). Alexithymic patients tend to be inexpressive and emotionally "restricted" and have difficulties bonding with others (Taylor, 2000). The occurrence of separation and divorce is higher in this population than in the normal population. Alexithymia as evaluated with the 20-items Toronto Alexithymia Scale (Bagby, Taylor, & Parker, 1994) affects about 15% of the general population with a slight over-representation of men.

This disorder is often associated with personality disorders, addiction to substances such as alcohol, toxics, and sedatives and eating disorders like binge eating. It is also often associated with somatic disorders (arterial hypertension, anger, asthma, etc.).

Emotional Avoidance

Even when they are suited to life circumstances, negative emotions (sadness, fear, shame, anger, stress) may generate stress if one does not feel one has control over them. They may also generate fear (that they will never end) or shame (at the idea that one is the only person to whom this happens). In these cases it is not one but two emotions that distress the mind and body (Greenberg, 2002). In a sense, it becomes twice as hard to cope with emotions (see figure 27.2). Thus negative emotions like sadness and anger that should be restricted in time turn into long-lasting negative moods such as depression or sustained resentment. Since negative emotions are often experienced as pain in the body, secondary emotions (Greenberg & Paivio, 1997) might lead to the development of chronic pain.

lead to loss of control over behavior; (3) fear of other people's judgments; (4) the fear that intense body arousal that results from the emotion could be a major disease (Williams, Chambless, & Ahrens, 1994). When an emotion is perceived as bearable and is accepted, no conscious effort is made to suppress it, and mood stabilizes spontaneously. Conversely, efforts to suppress emotions exacerbate them and are at the core of most mental disorders.

Since this disorder has only been recently identified, there is no real estimation of its frequency of occurrence in the general population, although Barlow argues that it is responsible for most mental disorders (Barlow et al., 2004).

Meditation-Based Emotion Regulation

The new meditation-based approach to emotional dysfunction emphasizes the advantages of the development of body perception of emotion, then identification and acceptance through meditation (S. C. Hayes, 2004). Thus, for example, in moving meditation such as yoga, what seems to be efficient in regulating emotion is self-observation, concentration, and acceptance; during this process attention is placed on sensations, and impermanence acts as a background mind-set (Campbell & Moore, 2004). Talk therapy (purely intellectual therapy) seems more limited.. "The absence of direct connections from the PFR-L to the amygdala may be related to why talk therapy for psychiatric conditions that involve amygdala-related conditions is relatively inefficient (in terms of the amount of time required to achieve a therapeutic effect)" (LeDoux, 2002, p.292).

Meditating is thus a way to deal with dissociative disorders through the development of a mindful attitude. It is also a way to deal with alexithymia in that it helps patients increase emotional intelligence and enhance their emotional tolerance through exposure to emotions. Different types of thoughts suppression in all mental disorders are causal factors in long term increase of emotional arousals and appraisals (Levitt, Brown, Orsillo, & Barlow, 2004). Meditation thus can be used to prevent the use of avoidance strategies, which involve physiological arousal (interoceptive) avoidance and cognitive avoidance (use of other thoughts as distraction), procrastination and worrying (avoiding emotionally salient tasks) and rumination in depression (Nolen-Hoeksema, 2000).

Meditation-Based Protocols and Depression

Medication-based therapy as well as psychotherapies (cognitive therapy and interpersonal therapy) are successful in curing punctual depressive episodes but fail to prevent relapses. After three major depressive episodes, the probability of relapse is about 90%. In addition, the continued use of antidepressant over several years may be problematic because of the presence of side effects and addiction issues. Finding alternative treatments has become critical, especially since the World Health Organization predicts that in 2020 depression will be the

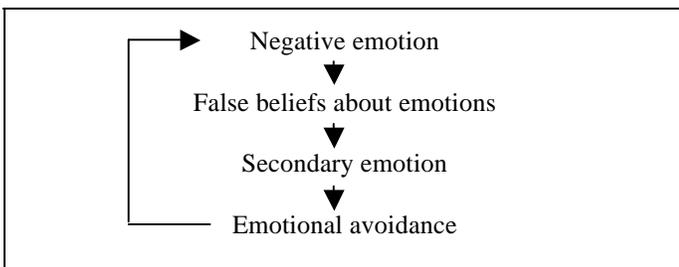


Figure 2. Emotional intolerance model

Patients who experience emotional avoidance can have four types of fearful ruminating thoughts: (1) fear that the emotion will never end; (2) fear that the emotion will

ranked second most common illness worldwide. Meditation-based clinical intervention can help tackle this major health care issue.

About 40 studies have shown that, once treated with a meditation-based protocol, patients do not differ from subjects without depressive history in regard to the amount of negative thoughts they have (Ingram, Miranda, & Segal, 1998). Instead of studying thoughts' effects on mood, some researchers have also studied mood's effects on thoughts. For example, Teasdale (1983, 1988) showed that experience-induced sadness (induced by sad music or sad reading material) had more impact on subjects with a history of depression than on control subjects (Segal & Ingram, 1994). Negative emotions thus seem to have a more lasting effect in subjects who have suffered from depression. Reactivation of negative thoughts in these subjects preserves and deepens sad moods through a series of vicious cycles. Sad moods can thus generate lasting negative thoughts to the point that a slight mood impairment for these patients can trigger disastrous changes in thought patterns and can be responsible for the persistence of depression and relapses.

Cognitive reactivity describes the ability of a slight change in mood to degenerate into a series of deeply negative thoughts. Cognitive reactivity has a cumulative impact: each depressive episode increases the probability of a new one since, with time, the depression circuitry is more readily activated. Early depressive episodes are most often preceded by significant negative events but as new episodes occur, the role played by these events becomes less clear. Each new episode seems to lower the threshold for depression onset. With time, this threshold tends to get so low that depressive episodes seem to occur spontaneously. Even when an episode of depression is over, cognitive reactivity remains and puts the patient at risk of suffering another episode. Changing a person's relationship with his or her own thoughts and negative emotions—in a way that doesn't directly act on the content of thoughts—is key to stopping the vicious cycle of cognitive reactivity.

Jon Kabat-Zinn relied on mindfulness-based practices to put distance between the patient and his cognitive, emotional, and sensory experiences (Kabat-Zinn, Lipworth, Burney, & Sellers, 1986; Kabat-Zinn et al., 1992). Kabat-Zinn's mindfulness-based stress reduction program has become widely popular since about 1970 and is now often accepted in clinical settings. MBSR is a structured group program composed of 8 two-hour weekly sessions. Sessions are centered on mindfulness practice (simple Zen-like mindfulness meditation) and experiential feedback. Participants commit to practice at home for 45 minutes daily, at least 6 days a week. MBSR has been shown to be efficient for stress reduction (Davidson et al., 2003). Mindfulness-based cognitive therapy (MBCT) is largely based on Kabat-Zinn's stress reduction program and has the same format as MBSR except that it makes use of cognitive therapy in addition to meditation (McQuaid & Carmona, 2004). MBCT therapy has proved to be efficient, as it reduced the

probability of relapse by about half among patients who had experienced at least three major depressive episodes (Michalak, Heidenreich, Meibert, & Schulte, 2008; Teasdale, Segal, Williams, Ridgeway, Soulsby, & Lau, 2000).

Here is how Kabat-Zinn (1990) describes the emotional detachment process: "It is remarkable how liberating it feels to be able to see that your thoughts are just thoughts and that they are not "you" or "reality"... The simple act of recognizing your thoughts as thoughts can free you from the distorted reality they often create and allow for more clearheadedness and a greater sense of manageability in your life. Mindfulness thus provides a method for detachment that turns into recognizable changes in mood. Kabat-Zinn's mindfulness does not teach people how to avoid unpleasant emotions and life events: it only proposes to teach people how to live with them.

Thus asking patients to perform a particular task (i.e., meditation) when negative thoughts cross their mind may help them to abstain from totally identifying with these thoughts. It automatically puts some distance between the patient and his or her negative thought-affect and allows the patient to tolerate these thoughts better. It also absorbs the patient's focus of attention and the limited information-processing resources of the brain, thus allowing the patient to avoid the ruminative loops of thought-affect. Eye movement desensitization and reprocessing (Shapiro, 1999), a technique that involves performing repetitive eye movement while recalling traumatic events, most likely works on the same principle, although it lacks the emotional intelligence component that is characteristic of meditation-based interventions.

Meditation-Based Emotion Exposure

Meditation protocols are powerful clinical interventions and should not be taken lightly. For instance, some form of concentrative meditative practices could lead to emotional avoidance, as they instruct practitioners to direct their attention to a specific object while ignoring all others, including negative thought-affect. They could thus train patients to avoid negative thought affect, leading to with potentially significant consequences.

MBSR and MBCT are suitable to use to prevent relapses in depression but require adjustments when applied to intense negative emotions in patients with emotional trauma. The procedure used in these practices could lead to a form of emotional avoidance, as the attention is intentionally and plainly redirected toward specific emotional material. Below, we provide an adaptation of these practices that relies on breath awareness meditation (a basic form of meditation inspired from Zen and Vipassana), which is less abstract and easier to achieve than mindfulness for beginners.

The meditation-based emotion exposure (MBEE) protocol has been described by Hahusseau as grouping together all elements of the emotional psychosomatic process. It is mostly inspired by MBSR and MBCT. However, MBCT and MBSR involve standard meditation

followed by cognitive assessment. In contrast, MBEE, like acceptance cognitive therapy and eye movement desensitization and reprocessing, places the emotion at the center of the meditation practice.

1. Chose a target emotion and assess the discomfort it creates here and now on a scale of 1– 10. It can be:
 - A pervasive negative emotion
 - A painful sensation
 - The image of a recurrent memory
 - An intrusive and compulsive thought or belief
 - A worry
2. Put yourself in respiratory sinus arrhythmia by
 - a. Isolating yourself
 - b. Closing your eyes
 - c. Placing your attention around the nostrils, the ribs, or the abdomen without trying to slow down or change your breathing, but simply observing your breath and breathing sensations
 - d. Trying to feel both your cardiac rhythm and respiratory movements in the same areas of the body.
3. Use the following guidelines to expose yourself to emotions for at least 30 minutes while keeping the eyes closed. The only goal here is to follow your attention and to be aware of where it goes, while remaining aware of the breath. Whatever thought arises in your mind or sensation in your body, simply observe it, without judgment, and with the kindest and most compassionate attitude possible (Lutz et al., 2004; Neff, 2004), without any desire to change it or to ease the pain, simply following the breath until the breathing cycle is complete.
 - a. Intentionally direct your attention toward the target emotion until your attention becomes attracted by another thought, emotion, or object.
 - b. Observe, without any judgment, where your attention is being drawn.
 - c. It is possible that you might experience a physical sensation. In this case, follow the breath toward this sensation, not trying to stop or resist it, but simply trying to feel it. If it is painful, simply observe how much pain you feel.
 - d. If your attention is attracted by some mental content—a thought, a memory, a worry, a question—observe this content as if it were written on a screen and at the same time feel what happens in the body. What bodily sensation is present? Observe how much this thought and its associated feeling proves that you are suffering now. Try to label the emotion you are experiencing (sadness, anxiety, anger) and stay in touch with it.
 - e. If you realize your attention is lost in other thoughts, begin again, using the initial target emotion.
4. After emotion exposure:

- a. Assess again the discomfort you feel on a scale of 1–10.
- b. Briefly write down what you observed during the exercise.
- c. In the following hours, observe if anything has changed since before the exercise.

Clinical Application of the MBEE to Binge Eating Disorder

Following a failure of classic behavioral therapy with a patient suffering from an eating disorder, Hahusseau tested the meditation-based emotion exposure protocol described above. The literature shows that 20%–50% of patients with eating disorders have a traumatic history, such as sexual abuse during childhood. Traumatic history is neither sufficient nor necessary for an individual to develop an eating disorder. However, it is known that a combination of abuses, such as an unfavorable family environment (Vanderlinden & Vandereycken, 1997), significantly increases the probability of binge eating (Hastings & Kern, 1994).

It is hard for eating disorder patients with traumatic histories to regulate their emotions (Van der Kolk, Pelcovitz, Roth, Mandel, McFarlane, & Herman, 1998). Self-mutilation and addiction to benzodiazepine or alcohol are found in 70% of eating disorder patients with a traumatic history, but in only 15% of eating disorder patients without a traumatic history (Gleaves & Eberenz, 1994). The frequent combination of abuse (Barker-Collo, 2001), dissociative disorder (Maaranen, Tanskanen, Haatainen, Koivumaa-Honkanen, Hintikka, & Viinamaki, 2004), and eating disorders (L. Brown, Russell, Thornton, & Dunn, 1999) eventually led Hahusseau to offer her patients MBEE.

Here we describe two case studies that illustrate use of the protocol and demonstrate its potential efficacy. Some studies have already started investigating the benefits of meditation for eating disorders, particularly for binge eating disorder (Kristeller & Hallett, 1999), and protocols were judged to be “most likely efficient treatments” (Baer, 2003, p. 129). MBEE involves first collecting anamnestic data (patient history), then training the patient to perform the emotion exposure protocol and guiding him or her through it. The protocol has been split in two sequences: past-emotion exposure sessions are done at the therapist’s office and current-emotion exposure sessions are done twice with the therapist, then at home by the patient on his or her own.

Françoise

Françoise was married with two kids. She was 52 years old and 5 feet 7 inches and weighed 233.2 lbs for 20 years. Françoise was a nurse and had a history of postpartum depression. She wished to see a therapist for binge eating disorder and her uneasiness at work. She had already done two 8-year-long psychotherapies. Her weight anamnesis revealed that her father called women “fatty” and she gained considerable weight after her children’s birth. She snacked

excessively and was not physically active. At work she felt insecure during planning discussions, and she always agreed to do the most demanding tasks. Her colleagues disliked her and saw her as too obsequious. She was aware that her fear of her colleagues' criticism was unreasonable and that her behavior was not appropriate but she did not seem to be capable of changing it. She did not dare say "no"..

The primary therapeutic hypothesis was the following:

- Her social situation leads to negative emotions.
- Negative emotions lead to assertion disorder and submission.
- Assertion disorder and submission lead to dissatisfaction.
- Dissatisfaction leads to snacking.
- Snacking leads to more negative emotions.

The therapeutic plan initially consisted of the behavioral exercise of positive self-assertion (Stravinsky, Marks, & Yule, 1982). Although she was motivated to complete the assignments and was consistent in doing so, the first 30 sessions did not provide satisfying results. She failed to successfully assert herself and her intense negative emotions remained unchanged. She still could not express herself at work. No weight change was observed during this initial therapeutic approach.

She then tried MBEE. The chosen past emotion related to her father beating her brother in front of the whole family. Françoise experienced repetitive traumatic reliving of scenes between her father and brother. As the youngest child in her family, she had felt neglected growing up. Her mother's submissiveness and father's inflexibility and violent fits also added to her feelings of insecurity. As a child, her primary emotion (Damasio, 1994) or behavioral tendency (Frijda, 1986) was passive submission. Since then she had suffered from dissociative disorder.

Recalling the violent scenes between her brother and father produced anxiety, extreme insecurity and helplessness, and feelings of guilt, sadness, and anger. During the emotion exposure protocol, her somatic response was severe and involved abdominal pain and accelerated breathing rate. She rated her reaction as 7 on a 1–10 subjective intensity scale. The emotion exposure protocol allowed her to release these intense emotions and other emotions associated with traumatic memories, such as her sexual molestation by a doctor, her father's insults when she was 18 years old, and eventually her brother's suicide. The total exposure consisted of 30 sessions of 1 hour each with two sessions devoted to learning the protocol so she could practice emotion exposure at home on her day-to-day experiences.

Within a year Françoise lost about 66 lbs; she is now involved in sports and is happy to feel her body again. At work she is now at times assertive, expresses her feelings, and no longer runs away from conflict. She is now more

accepting of herself. Today, after 3 years, she still weighs 167 lbs.

Anabelle

Anabelle was a 45-year-old seamstress. She was 5 feet 3 inches tall and weighed 211 lbs. She wanted to consult a psychiatrist for problems in her relationship and for her eating disorder (for which she is also considering gastric bypass surgery). She and her twin brother were the youngest in a family of six children. Her mother had been diagnosed with psychosis. Anabelle was divorced with two children ages 20 and 24. She had been in treatment for 5 years and regularly used benzodiazepines to ease her anxiety. Her treatment at the onset of the emotion exposure protocol was Seltraline-50 once a day and 10 drops of haloperidol. Her eating disorder had begun a year prior to her divorce, when she was 32. Her weight had increased ever since, and her behavior reflected her shame: she would close the door of her home quickly so the neighbors would not see she was overweight. She had one eating crisis per day, she seemed to be emotionally unresponsive, and her colleagues at work rejected her. She had had a difficult childhood and was often kept awake by her psychotic mother's scream at night. She and her siblings regularly experienced violent attacks by her father. At 10 years old, she was sexually abused by her brother-in-law and, as a result, suffered from dissociative disorder. When she recalled this traumatic event, she rated it as 6 on a 1–10 pain scale.

Anabelle attended a total of 20 sessions: 10 sessions of 30 minutes for data collection and functional analysis, then nine 1-hour sessions dedicated to MBEE targeting the traumatic event, and finally a 2-hour session dedicated to learning the technique so she could learn it at home on her day-to-day emotions. After the second emotion exposure session, Anabelle started to lose weight without effort.

She now weighs 172 lbs and has changed her mind about having gastric bypass surgery. She regulates her emotions by crying. She once again feels her body, can experience satiety, and believes she is making progress addressing her dissociative disorder. She decided to stop taking antidepressants during the emotion exposure treatment. Today, after 6 months, she has not regained weight.

Toward Objective Marker of Emotion Exposure

Emotion regulation describes an individual's capacity to adjust from a high arousal level produced by sympathetic nervous system activity to a less elevated one, which depends on the parasympathetic autonomic nervous system (Gross, 1998). Some measures of autonomic system activity such as heart-rate variability (HRV) can thus be used to assess emotion regulation. As we have seen, one primary effect of meditation is to spontaneously activate the parasympathetic system. Systematic observation of patients' HRV recordings during the MBEE revealed that each of its steps (feeling, labeling, compassionate acceptance)

influenced the 2- to 3-second cycle sinusoid component of heart-rate variability. In the meditation-based emotion exposure protocol, the unique instruction given to the patient is to observe without judgment—and while breathing—his or her emotional, cognitive, imaginary, sensorial material.

Various meditation practices have been reported to induce an overall increase in HRV (Bernardi et al., 2001; Cysarz & Bussing, 2005; Ditto et al., 2006; Lehrer et al., 1999; Phongsuphap, Pongsupap, Chandanamatta, & Lursinsap, 2007; Takahashi et al., 2005), which is most often interpreted as an increase in parasympathetic over sympathetic activation. The protocol could help suppress cortical influences on the sinus node that could disturb the heart's autonomic regulation (Craig, 2005); however, tasks that involve changes in respiratory rates must be carefully analyzed to avoid flaws in HRV interpretation (Grossman & Taylor, 2007). Furthermore, in dissociative disorder patients, it is possible to observe in the HRV time series a decrease in activity of the autonomic nervous system, as shown by a study of skin conductance measure (Sierra et al., 2002). HRV would then reflect activity from efferences of the central autonomic network (Thayer & Lane, 2000) and could be used to measure the presence of voluntary control over emotions, called avoidance, or its absence, called acceptance.

Though further study is necessary before a link can be made between meditation-induced increase of the HRV and emotion regulation, preliminary results suggest that HRV could be used as both an emotional exposure marker and a meditative state marker. A better understanding of the origin of HRV changes during different meditation practices may help us understand the mechanisms behind meditation-based emotion regulation.

Conclusion

Meditation promotes both physical and mental well-being and contributes to the development of positive emotional traits (K. W. Brown & Ryan, 2003). It is thus important to integrate its active principles in therapies for patients suffering from physical diseases and mental disorders (Bishop et al., 2004). Becoming aware of the fluctuating quality of thoughts, sensations, emotions, and other internal phenomena helps reduce dissociative disorders and the perceptual narrowing that these disorders induce. It also helps reduce alexithymia and emotion avoidance, in which a large number of psychiatric disorders are rooted.

As we have seen, meditation-based interventions such as mindfulness-based stress reduction and mindfulness-based cognitive therapy are already being used in depression relapse prevention programs. These techniques have also been modified and adapted for the treatment of acute disorders such as chronic pain, depression, fibromyalgia, and psoriasis, as well as anxiety, eating, and psychosomatic disorders. In all cases, results have been encouraging and support its use in therapeutic practices (Baer, 2003). In the years to come, we hope to see the development and

validation of more meditation protocols adapted to specific disorders.

In the case of eating disorders, the disorder can sometimes be simplified and regarded as resulting from a traumatic emotional experience. Under genetic predisposition and in the context of an adverse social or familial environment, eating disorders foster complete avoidance of negative emotions. Thus, as current negative emotions are instinctively avoided due to early traumatic experiences, eating crises appear to be a preferred mode of emotional shunning. Emotional dissociative disorder and binge eating disorder appear to have identical functions: to suppress the natural emotional process (feeling, labeling, accepting; Hallings-Pott, Waller, Watson, & Scragg, 2005). HRV during MBEE session turns out to be an excellent index of emotion regulation capacity, which is the capacity to feel, label, and accept emotions. The combination of high levels of respiratory sinusual arrhythmia achieved during meditation, enhanced emotional regulation, and the use of more suitable coping strategies has proved useful for weight loss (Fabes & Eisenberg, 1997).

The diverse effects of meditation on the body and cognitive and affective processes are beginning to be understood, and these techniques are now used in clinical settings for patients suffering from emotional and attentional disorders. The wide range of observable effects of attentional training during meditation allows us to study the multiple connections between the mind, brain, and body. Such connections are increasingly being acknowledged, and their investigation offers new pioneering approaches both in clinical practices and in fundamental cognitive neuroscience research.

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Research with mindfulness and meditation is really still in its infancy. Even with that, a number of studies have investigated changes in brain activation both at rest and during very specific tasks that are associated with the practice of mindfulness meditation. Mindfulness Versus Medication: What Can We Prove? By practicing mindfulness and meditation, you can then begin to more fully understand how your emotions, thoughts, and feelings impact your life. If you want to take one small step in support of a happier, healthier, and calmer way of life, mindfulness and meditation is a great place to start. References. Neuroscience of Mindfulness: What Happens to Your Brain When You Meditate. Abstract | Research over the past two decades broadly supports the claim that mindfulness meditation "practiced widely for the reduction of stress and promotion of health" exerts beneficial effects on physical and mental health, and cognitive performance. Challenges in meditation research. Box 1 | Mindfulness meditation. Box 2 | Imaging the meditative state. Changes in brain structure. Table 1 | Structural changes in the brain associated with mindfulness meditation. Mindfulness and attention.