Meditation, Contemplative Spirituality, and Brain Science

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1 Introduction

Venerables, ladies, and gentlemen, we work at Naropa University, a Buddhist inspired institution of higher learning in the United States with about 1200 full time students. Fortunate to be located in the Rocky Mountains which are beautiful, inspiring, and very sacred, Naropa University offers Bachelors and Masters degree programs in psychology, religious studies, environmental studies, the arts, interdisciplinary studies and several distance education programs. We even use the internet to teach meditation to people living in places located all over the world.

A two-hour drive from Naropa brings visitors to a retreat facility known as The Shambhala Mountain Center. Many academic departments from Naropa University use this 600-acre (243-hectare) facility for group meditation and contemplative retreats as part of undergraduate and graduate education. Figure 1 shows the Great Stupa of Dharmakaya Which Liberates Upon Seeing. This stupa is 108 feet tall, and contains three floors of interior rooms that are used for a variety of meditation practices. This sacred structure commemorates the life and teachings of Chogyam Trungpa Rinpoche, who founded Naropa University in 1973.

Figure 1. The Great Stupa of Dharmakaya which Liberates upon Seeing.
This stupa is located in the Colorado Rocky Mountains at an elevation of about 8,000 feet (2,438 meters) above sea level, and embodies the sacred teachings of Chogyam Trungpa Rinpoche, founder of Naropa University.

Dr. Francisco Varela helped found Naropa University in the early 1970s and devoted the last years of his life to integrating scientific and contemplative perspectives in an approach he called "neurophenomenology." He pioneered the measurement of brain activity of meditators trained to carefully observe their own experience. In our own work, we programmatically explore the experience of meditators using methods developed by researchers who themselves meditate, in an approach known as "grounded theory." The Naropa University Consciousness Laboratory is a training and research facility that seeks to gain greater understanding of human capacities for awareness by helping to develop contemplative psychological science. We use the methods and concepts of science to empirically explore meditation and contemplative spirituality. By investigating the experience of meditation practitioners, we come to better know the transformational processes by which those engaged in meditation and related teachings develop emotionally, cognitively, and spiritually. We have been learning about spirituality in the lives of meditators who have been sampled from a variety of religious traditions. We aspire to be of benefit to others through this research.

In order for us to discuss meditation and contemplative spirituality with some precision, it will help to define a few key terms. “Spirituality” encompasses the varied experience of vitality, life force, divinity, sacred, and so on. “Contemplative” concerns a person’s reflective approach to observing their own experience. The two can be related in that, for many people, engaging in a contemplative activity, or even adopting a contemplative attitude, can lead to more spiritual experience. We use the phrase “contemplative spirituality” to refer to reflective approaches to working with spiritual experience and spiritual development.

We use the phrase “open awareness” to refer to something that can be encountered directly in people’s experience, though it is rather tricky to put into words. In fact, before defining open awareness, we must invoke an important caveat. For any concept used to trace actual lived experience, it would be a mistake to think that the referential concept is the same as the actual experience itself. That would be analogous to thinking that when somebody uses their finger to point to something, we need only look at the finger to find out what we need to know. An ancient teaching famous in Buddhist circles uses the example of a finger pointing to the moon to offer a lesson in not mistaking a pointer for that which is pointed to. Modern academic culture has more recently offered the slogan “the map is not the territory” to reflect this same insight.

With that distinction in mind, we understand open awareness as having the quality of being wakeful, alert, and highly cognizant without necessarily any hint of the anxiety that so often accompanies vigilance. Open awareness is imbued with a sense of opening or expansiveness that extends beyond any boundary or limitation. Open awareness involves a thorough resting that can be calm, relaxed, quiet, and even serene. Open awareness is thoroughly compatible with a stable sense of clear contact with the physical world, embodied presence in the here and now, unadulterated by machinations of thought.

Finally, we also define a pair of terms that contrast with each other regarding content of experience and capacity for open awareness. By “clarity” we mean contents of consciousness arising together is a shared space of awareness, that is, a person genuinely relating to all of one’s own experience. In contrast, “confusion” refers to experience that overwhelms one’s capacity for open awareness, for example, two or more thoughts colliding, resulting in obscuration of some content.

This chapter concerns the role that brain processes play in our experience of open awareness. First, we address how the human brain works: mental functions and subjective experience are orchestrated by vast interconnected networks of brain cells called “neurons.” Next, we advance a theoretical framework that establishes a role for particular patterns of communication between neurons in subserving conscious awareness. We then distinguish between two modes of brain activity which correspond to the subjective disparity between clarity and confusion. This combined understanding of physiological activity in the brain on one hand, and mental life on the other, equips us to then examine the psycho-spiritual and physical development that results from contemplative practice as exemplified by meditation. Recent neurophysiological findings from laboratory studies of meditators shed light on the neural substrates of meditative experience. These exciting empirical results are consistent with and support our theoretical framework that relates spiritual experience to corresponding brain activity. After considering these neuroscientific data with regard to contemplative psychological theory, we then suggest further steps for future research to take along these lines.

2 Brain Science

A few key points can help us to understand how the brain is involved in conscious experience. Each living human body contains a vast web of intricately networked neurons, cells that are constantly communicating with each other via neurotransmitter chemicals. A brain supports human consciousness by virtue of the communication between these brain cells, and the dynamic processing that occurs within this communication. Some parts of the human brain are specialized to facilitate communication between other parts of the brain that are not directly interconnected with each other. This anatomically organized system of communication across brain areas constitutes a physical framework that allows distinct subsystems within the brain to function in either of two modes, one in relative isolation from each other, another in which they work more interdependently, that is, with greater coherence. It will help to first review the nature of inter-cellular communication that occurs between neurons, before proceeding to a more systems-level analysis.

2.1 Communication among Brain Cells

The principle function of a neuron is to produce signals that influence the activity of other cells. Figure 2 shows one neuron in isolation, which is a bit odd because neurons are like people in the sense that they are never alone. A neuron is only alive and functioning by virtue of the neurons to which it is connected. The dynamic nature of a living brain is evident in the ever-present signaling between neurons. For this and subsequent figures, see figure caption for explanation of figure components.

Figure 2. Brain Cell (Neuron).
Each neuron receives incoming signals from thousands of other brain cells. Each brain cell uses its elongated projection (axon) to transport information across distance to be communicated as input to other neurons thousands of other neurons.

Actual brain tissue viewed at the microscopic level contains many neurons arranged together. Brain function hinges on the connections between neurons, the physical contact which

transports signals between brain cells. Electrical changes in neurons reflect their communication or signaling and can be measured with electrodes placed on the scalp. As a connected ensemble, this nervous system conducts the internal orchestra of physiological functions as well as coordinating bodily movements.

Cortex, the large and thickly wrinkled outermost portion of the human brain, contains layers of neurons that together appear as the so-called "grey matter" of the brain. The cortex and its connections are critically important for conscious experience by virtue of the intricate circuitry comprised of interconnected neurons (Grossenbacher, 2001b). A neural circuit is a set of connected neurons which transforms one set of signals that it receives into another set of signals that it conveys to other circuits. A typical neural circuit is comprised of numerous neurons that reside together within an anatomically localized area. The specific computations made by a circuit are determined by its functional architecture, which typically includes both excitatory and inhibitory connections. Inhibition plays a very important role in the governing of brain activity. If there were only excitation, with neurons exciting other neurons to become ever more active, than we would all be having seizures very quickly. It is by virtue of inhibition that some neurons tell others to quiet themselves, to reduce their level of activity, so that we have the possibility of balance in our brain.

Neurons are connected together in pathways, as depicted in Figure 3. We have learned in the last decade or two that the brain's pathways are not limited to information flowing in only one direction. Rather, the feed-forward signals conveyed in one direction along the pathway are reciprocated by other neurons that send their elongated projections (axons) back in the other (feed-backward) direction. Therefore, neural pathways within the brain are really like a two-way street, in that information flows in both directions.

Figure 3. Neural Pathway with Signaling in Both Directions.
Neurons are connected together in pathways, with information flowing in both directions carried by two sets of neurons. The top portion of depicts interconnected neurons signaling in a feed-

forward, shown arbitrarily as left to right. These feed-forward signals are reciprocated by other neurons, shown at the bottom of this figure, that send their back in the feed-backward direction.

2.2 Systems-Level Communication Involves Access Mediation

The Access Mediation Model (AMM) of human consciousness offers a basis for understanding how neural circuits located in distinct parts of the brain may be put in communication with each other (Grossenbacher, 2001a). According to this anatomical model of awareness, human brains evolved by augmenting this capacity for mediating mutual access across a variety of neural circuits each devoted to their own specialized domain of processing. The area of cortex known as "anterior cingulate gyrus" is thought to contain neural circuits that play such an intermediary role, putting brain cells contained in disparate circuits into communication with each other (Grossenbacher, 2001a).

Though in any given moment, the psychological functions associated with disparate parts of the brain may be put into communion with each other via mediation, this need not always occur. The mind can also function when distinct processes each proceed in relative isolation from one another. Indeed, as easily made evident by phenomenological observation, for many people, moments of experience vary according to whether more or less mental contents appear together in a mutually cognizant manner, that is, within a shared space of awareness. AMM describes the neural substrates of this variation as hinging on the degree to which mediating neural circuitry brings the products of specialized (content-specific) neural circuits into communication with other neural circuits that are specialized to process information in other domains.

For example, one part of the brain located in temporal lobe of cortex supports the mental function of comprehending spoken language, and an entirely distinct part of the brain located in the parietal lobe of cortex processes the spatial location of seen objects. Consider the case in which a person is aware of listening to spoken words but remains unaware of where visual objects appear. AMM asserts "Any … conscious content must pertain to cortically represented information which is communicated to other parts of the brain via mediation by content-general circuits" (Grossenbacher, 2001a). Thus, in the case of consciously comprehending speech, outputs from the temporal area involved in comprehending speech must be provided with mediated access from neural circuits located in other brain areas. AMM also tells us "If a content-specific cortical area lacks mediation for its outputs via the content-general circuits which mediate inter-cortical communication, then the information as processed within this cortical area is inaccessible to consciousness" (Grossenbacher, 2001a). Thus, in the case of unconsciously localizing visual objects, outputs from the parietal area involved in visual localizing must currently lack mediated access with other neural circuits.

In summary, neural communication has been found to occur between individual neurons as well at higher organizational levels at which neural pathways enable inter-circuit communication. As a neuro-coordination model of psychological integration, AMM asserts that interaction among interconnected neural circuits provides for the variations in conscious awareness that humans experience. For example, the subjective salience of one content in awareness (e.g., comprehending spoken words) depends on how much bandwidth is provided by mediating circuits (and pathways) to bring the neural signals output from the relevant content-specific circuitry (e.g., within the left temporal lobe of cortex) to light in the pool of awareness (Grossenbacher, 2001a). We advance this line of theorizing by proposing that patterns of neural

communication that involve more mediated access support more open awareness. Subsequent sections of this chapter delineate important ramifications of brain function, and then relate these to experiential aspects of contemplative spirituality.

3 Two-Mode Theory of Brain Activity and Experience

Given the vast complex of inter-communicating brain circuits, we next introduce a new theory that distinguishes between two modes of neural signaling among parts of the brain. The experiential correlates of this neurobiological dichotomy are then described. This theory provides a basis for advancing our understanding of meditation and spirituality with regard to mind and body.

3.1 Divided and Unified Modes of Neural Communication

The brain is so complex that one part may have neurons communicating with each other in a way works at cross purposes with the communication among cells in other parts of the brain. This "divided mode," wherein the activity in one neural circuit runs counter to the activity of another, simultaneously active circuit, may result from insufficient mediated access between the content-specific neural circuits involved. Divided mode is evident in the above example, in that the outputs of visual object localization circuits are divided from the consciously accessed comprehension of spoken language. If a functional activity in one part of the brain is not currently provided mediated access, despite there being anatomic potential for this mediation, then the process associated with this part of the brain is divided from others.

However, the entire brain is one unified physiological system, and it may have the capacity to function so coherently that no part of it is working in conflict with other parts. This "unified mode" could result from sufficient mediated access between the content-specific neural circuits that are active. In a modification of the example provided earlier, if circuits involved in speech comprehension and visual localization were mutually informed through mediated access, then at least with respect to these two processes, the brain would be operating in unified mode. The distinction between divided and unified modes thus hinges on whether the distinct neural circuits are put into communication with each other via mediating circuits.

We can think of the distinction between divided and unified modes as analogous to branches of a tree. The upper branches receive the benefits of direct sunlight: their leaves engage in photosynthesis, converting sunlight into energy, relatively more than lower leaves, but they are also more exposed to the dangers of wind and storm. In contrast, the lower branches are striving to reach closer to direct sunlight, while nestled underneath the upper boughs. The upper branches and the lower branches hold very different perspectives. This is analogous to when brain activity is divided: one part is doing one thing, another part is doing something else, and the two parts are functioning so independently that neither has any sensitivity to what the other is doing. Does experience in a single moment feel more like a single branch, or the entire tree?

Physiologically, the distinction between unified and divided modes depends on the interplay between (1) capacity for coherent communication among neural circuits, and (2) rate of output from content-specific neural circuits, as seen in Figure 4. We are careful to designate the horizontal axis as *capacity* for physiological coherence, rather than current level of physiological coherence, because (as is explained later) *current level* of coherence is subject to rapid fluctuation. We recognize that a brain's *capacity* for physiological coherence changes much more slowly than do current levels of coherent activity. Regardless of the current rate of output from content-specific circuits, unified mode is understood as this rate not exceeding the brain's

capacity for physiological coherence. Alternatively, divided mode corresponds to a rate of output which exceeds the capacity for physiological coherence. That is, in divided mode, the current rate at which content-specific outputs are produced in the brain exceeds one's capacity for mediating these outputs in a coherent way.

We distinguish between two different conditions in which brain activity may occur in unified mode. In "stillness", there is little to no output activity from various neural circuits. In the other condition of unified mode ("luminosity"), there is enough activity in the brain for there to be highly energetic phenomenal display in awareness, but this does not exceed the high capacity for physiological coherence. Unified mode comprises a range from low content-specific output rate (stillness) to high content-specific output rate (luminosity). Regardless of content-specific output rate, brain activity in divided mode could be thought of as "neural cacophony" in that the amount of output signaling overwhelms the system's capacity for coherence.

Figure 4. Brain Activity Modes Depend on Capacity for Coherence and Output Rate.
The horizontal axis depicts an individual's capacity for coherence among neural circuits such as may be achieved through the mediated access mechanism described earlier. The vertical axis depicts the rate at which output signals are generated from each neural circuit that is devoted to specific content. The distinction between unified and divided modes of brain activity, demarcated by the long diagonal line, hinges on the relation between current rate and capacity. In unified mode, the output rate from content-specific circuits does not exceed the brain's capacity

for physiological coherence. In contrast, divided mode corresponds to a rate of output which does exceed the brain's capacity for physiological coherence. The lowest portion of the figure (stillness) designates the portion of unified mode characterized by low content-specific output rate. The upper-right portion of the figure (luminosity) designates the portion of unified mode characterized by a high output rate from content-specific circuits.

3.2 Divided and Unified Modes of Experience: Confusion and Clarity

What does divided mode feel like from the inside of the nervous system? Different things are simultaneously going on quite independently from one another. Psychologically, divided mode consists of two (or more) processes with independent processing streams that are ignorant of each other and thereby fail to participate in a shared or connected consciousness (because they do not have access to one another). This could feel chaotic or at least distracting. When in the divided mode, for example, we may be busy chattering away, like agitated monkeys let loose.

Unified mode involves coherent brain function and a lack of psychological conflict inside one's own mind (we present data below that support this interpretation). In unified mode, it is as if all brain functions were rowing a boat together, with all parts moving their oars in the water synchronously, together at the same time. Thus, the unified mode manifests as coherent physiological activity among different parts of the brain. Just as increasing access mediation provides a mechanism for increasing physiological coherence among neural activity across parts of the brain, so to increasing awareness may confer increasing mental coherence (clarity).

The subjective distinction between unified and divided (clarity and confusion) depends on the interplay between mental speed and capacity for mental coherence, as seen in Figure 5. We are careful to designate the horizontal axis as *capacity* for mental coherence, rather than current level of mental coherence, because (as is evident during personal introspection) *current level* of coherence may be subject to rapid fluctuation. Anecdotal observation suggests that a high level of coherence involves more a sense of aspiration or invitation than explicit control. For this reason, *capacity* for mental coherence may be relatively stable over periods of time such as hours, days, or even years. Regardless of the current level of mental speed, clarity is understood as mental speed not over-reaching the capacity for mental coherence. Alternatively, confusion corresponds to mental speed exceeding this capacity, that is, the current rate at which ideas are forming in the mind exceeds one's capacity for relating to those thoughts in a coherent way. The black arrows portray an example series of changes in capacity and/or mental speed over time. The line from A to B depicts an incremental increase in capacity for mental coherence, as might occur with maturation; the transition from B to C reflects a slight further increase in capacity together with a sizable increase in mental speed, as might occur in response to experience of profound insight; the line from C to D indicates a substantial decrease in mental speed that suffices to cross from divided into unified mode, as might occur, for example, during meditation.

Figure 5. Divided and Unified Modes Depend on Capacity for Coherence and Mental Speed. The horizontal axis depicts an individual's capacity for coherence among mental processes such as thoughts. The vertical axis depicts mental speed, the rate at which specific mental contents arise. The distinction between Unified and Divided, demarcated by the long diagonal line, hinges on the relation between current rate and capacity. In unified mode, mental speed does not exceed the mind's capacity for coherence. In contrast, divided mode corresponds to mental speed which does exceed the capacity. The lowest portion of the figure (stillness) designates the portion of unified characterized by slow mental speed. The upper-right portion of the figure (luminosity) designates the portion of unified characterized by fast mental speed. Black arrows depict changes over time through a series of points A, B, C, and D (see text for details).

Mental life can seem raging fast, which can be either very confusing or perhaps quite fun. Mental speed depends upon the rate at which ideas are passing through the mind. The speed of thoughts is analogous to water flowing. Sometimes it flows with a particular gentleness or finesse (which would be depicted in the lower portion of Figure 5). In other moments, thinking may be so vigorous and abundant that it overflows into overwhelm. In this case, a person has many thoughts occurring so fast that they exceed the mind's capacity for coherence (which would be depicted above or the left of the diagonal line in the figure). When the mind is overwhelmed by racing thoughts, many processes may be competing with one another for

mediated access to shared awareness. In this mental configuration, the totality of experience is often too difficult to keep within a single focus of awareness, or to appreciate in a fully conscious way. Thus, a person's sphere of consciousness becomes distorted or fractionated.

We distinguish between two different conditions in which clarity may occur. In "stillness", there is little to no content in various domains of the awareness. At the extreme, there is no object of awareness: not breath, not candle flame, not thought; nothing is happening. This degree of stillness corresponds to experience of open awareness as described earlier. In "luminosity," a contrasting manifestation of clarity, there is enough content of awareness for there to be highly energetic phenomenal display, but this in no way impedes open awareness. Open awareness mixes with whatever concepts happen to be arising.

In a purely conceptual experience, an idea fills up the mind to such an extent that non-conceptual experience is dissociated from awareness. This can happen with ordinary conceptual distinctions between good and bad, this and that, even self and other. At the other extreme, in purely non-conceptual experience (stillness), there is no concept whatsoever. Human experience also includes experience that is intermediate between these two extremes. When concept and non-concept mix together without exceeding one's capacity for mental coherence (luminosity), the idea persists, but there is much more space around the idea. In this case, the mind has not condensed itself to be filled entirely with the idea, but rather an abiding appreciation of vast space may accompany the conceptualization.

4 Contemplative Development and Spirituality

Audience Member: Can divided mode and unified mode happen together, or must this be sequential? Is it possible that people usually start with divided mode, and develop toward unified mode?

We next look at contemplative development from a few different perspectives. First, we discuss how contemplative development relates to both mental and neurophysiological coherence and awareness. Building on this foundation, we consider one aspect of self (de-centralization of self-concept) as it relates to psycho-spiritual development. The nature of self is then further illuminated by findings of changes in brain anatomy (neuroplasticity) in meditators. Finally, we consider the impact of contemplative training on a person's worldview.

4.1 Coherence and Awareness in Mind and Brain

How do spirituality and meditation relate to neurobiological coherence, as depicted in Figure 4, or to mental coherence, as visualized in Figure 5? The two-mode theory of brain activity and experience describes inter-related coherence in mind and brain. So, it is no longer necessary to address these two levels of coherence in isolation from one another, because mental phenomena and neurobiological activity are so closely correlated with one another.

4.1.1 Contemplative Development Relates to Coherence

A meditator's brain activity may shift toward unified mode (concomitant with a shift toward mental clarity) in either of two ways. Perhaps the most readily available route in any given moment is for the rate of output from neural circuits (along with conceptualization) to decrease, which could be seen as a downward movement in Figures 4 and 5. Given that a brain operating in divided mode may lead to conflicted behavior, methods for slowing one's speed of thought can prove beneficial. Another way for approaching unified mode is for the capacity for coherence to increase, which would appear as a rightward movement in Figures 4 and 5. If the

AMM-based account for neural coherence is correct, then it must be the case that change in an individual's capacity for coherence occurs over longer intervals of time, requiring a change in functional connectivity between content-specific circuits and mediating circuits. Through significant training and practice, meditators on a contemplative path may benefit from both rate decrease and capacity increase in their development toward clarity and unified brain activity.

During a meditation session, a practitioner may allow thoughts to flow freely without allowing other thoughts to attach to them, that is, to detract from the focus of attention. Like a faucet pouring water into a sink, letting thoughts collect risks overflowing the sink. Meditation facilitates the drainage of thoughts as they flow out of consciousness, allowing the mind to settle. By decreasing mental speed, meditation can eliminate competition between other mental processes such as thoughts, allowing for sustaining attention over longer periods. Ongoing processes then more easily access each other and thereby participate together in a unified conscious experience. People with sufficient contemplative experience know that mental speed can be very slow, perhaps even entirely still. By clearing the mind, or reducing the number of competing thoughts or processes, it becomes possible for many (or perhaps all?) ongoing processes to mutually access each other and thereby all participate together in unified conscious experience.

With training and practice, a person may increase or otherwise change their brain's capacity for coherently bringing together multiple contents of awareness. A meditator's increasing capacity for this kind of coherent experience is reflected physiologically, as seen in research on synchronization of activity among different parts of the brain, as described later. Contemplative practice cultivates awareness of all aspects of experience, including both confusion and clarity. Over time, awareness of alternation between confusion and clarity may contribute to an incremental increase in capacity for coherence. To what extent can the human brain, an anatomically unified system, function coherently? Is it possible for all neural circuits to work closely in accord with one another? Perhaps such a high degree of neurophysiological coherence corresponds to enlightenment.

4.1.2 Awareness and Contemplative Development

Glimpses of awareness happen to each of us at various times. Contemplative practices such as meditation train people to recognize these glimpses, invite them, and work intentionally with them. Learning experiences that occur during meditation (and other times) include insights about oneself, others, and the world at large. Noticing what is going on in the stream of consciousness as it wells up can lead to greater understanding of how one's own mind works. For instance, an individual may notice a process of blaming one's own unhappiness on another person. This recognition may come more readily after a person accumulates repeated experience with noticing thoughts which constitute the same or similar pattern. At any rate, by becoming explicitly aware of a particular thinking process as such, the person gains greater access to the possibility of alternatives to this thinking, thereby freeing the mind from its own self-imposed narrow-mindedness. In our example, it becomes easier to not blame someone else for one's own unhappiness. From the perspective of AMM, this can be understood as the output of the brain circuit involved in a particular thinking process being put into mediated contact with a larger number of outputs from other active brain circuits. The reflective consideration of one's own mental processes affords an opportunity for engaging life in ways other than habitual tendencies. Rather than narrowing the mind into an accustomed pattern, opening to a wider vista of

possibility invites open awareness. This shows the pivotal role that awareness plays in contemplative development.

In accord with this view, many participants in our ongoing research have reported that meditation helped them to notice more of what happens in their minds (Grossenbacher & Parkin, 2006). These participants reported that they notice more detail of their lived experience and more about how their mind works. In response to questions about meditation experience and the effect that meditation has had on their lives, one participant described "greater awareness of the space around me." Indeed, many meditators mentioned an increase in awareness, including awareness of body, emotion, perception, thought, and a wide range of content. From these data, we conclude that meditation results in the conscious experience of more content of awareness, often including a strong sense of embodiment.

Reported descriptions of awareness indicated transition during meditation from taking experience in an entirely personal manner to feeling less self-centered. In particular, as the pace of thoughts diminishes, sustained and focused attention illuminates interconnectedness throughout one's sensory, conceptual, emotional, and spiritual domains of experience. Meditation can enhance our ability to experience space around a concept, which helps to bring clarity into the use of rational thought and other mental faculties.

Some of our most compelling data relate meditation experience to participants' experience when they were not meditating. Experiences of interconnectedness and spaciousness that occurred first during meditation later become accessible in other circumstances. From this we conclude that meditation develops inner resources for maintaining open awareness when engaged in daily life. Thus, meditators draw on their own inner capacities that have been cultivated during the periods of time they intentionally set aside for practice.

4.1.3 Meditation Involves Neurophysiological Coherence

How does physiological coherence manifest in meditation? A very important brain-imaging study compared highly practiced Buddhist meditators with persons new to meditation (Lutz, Lawrence, Rawlings, Ricard, & Davidson, 2004). The Advanced Meditators Group was comprised of eight people who had been training and practicing various Buddhist meditations for over five years, some of them had practiced up to twenty years. For these participants, a resting condition was compared with metta, a loving-kindness meditation. The Comparison Group assembled ten non-meditating subjects, for whom a resting condition was compared with being instructed to think of a loved one with compassion. In this study, electrodes were placed on the scalp and brain electrical activity was recorded. Observations of the gamma band of brain electrical activity (oscillations in voltage between twenty-five and forty-two cycles per second) produced two provocative findings. When meditating, the coherence between the two sides of the brain (interhemispheric synchrony) increased significantly for the advanced meditators. The comparison group, who had only been trying meditation for a week, did not show this change. This result demonstrates a rapidly changing level of physiological coherence in brain activity. Moreover, it appears that meditative awareness is associated with increased physiological coherence across active neural circuits located in distant parts of brain.

In the rest state (where participants were not instructed to meditate), the advanced meditators showed more neurophysiological coherence than the novice meditators during rest. Thus, years of training and practice in meditation leads to greater physiological coherence in brain activity. Given the length of time (years) implicated in this study, this result supports our

understanding that each individual's capacity for physiological coherence in brain activity is slow to change (relative stability).

The publication of these experimental findings has ushered in a new era of scientific understanding about how different parts of the brain can communicate with each other in a coherent way. The reports of these meditators were that there was not a strong sense of "I" or object. Instead, there was an all-encompassing orientation of warmth toward sentient beings. We take these verbal reports as evidence for deemphasizing one's self-concept. The juxtaposition of these two findings suggests questions as to the relation between self-concept and coherence. Perhaps "getting oneself out of the way" fosters greater mutual access among distinct processes which can then be more fully shared in awareness.

4.2 Meditation Changes Brain Anatomy

Evidence presented earlier makes it clear that brain activity changes as a consequence of meditation. One of these changes involves an increase in capacity for physiological coherence after extended training and practice in meditation. Might such long-term changes in the brain's capacity for coherence involve actual changes in the anatomical structure of brain tissue? An elegant study used structural magnetic resonance imagery (MRI) to look at the shape and size of the anatomy of people's brains in order to compare practitioners of vipassana insight meditation with non-meditators (Lazar et al., 2005). Embodiment can be experienced subjectively, from inside the nervous system, as physical presence. Insular cortex is a part of the brain that is involved in experience of both bodily sensations and emotions. In meditators of insight meditation, this cortical area was found to be thicker in size in comparison to non-meditators.

The authors of that study explained that they do not know exactly how this difference came to be. There may be more brain cells in this part of meditators' brains. Or the number of cells may not differ between groups, but instead the shape and size of the individual cells could be different. A third possibility is that there could be other, additional kinds of cells in this area of cortex. The answer is not yet known. None the less, long time practice of insight meditation is shown in these data to change the size of a part of the brain.

This finding makes a lot of sense to us. Indeed, this result shows that meditation follows some of the same rules in its influence on the brain as does other behaviors. When someone spends ten-thousand hours or more in their lifetime practicing a particular skill, it changes them and it changes their brain anatomy (neuroplasticity). Many different kinds of experience have been found in recent years to be associated with neuroplasticity. Whether someone is an accomplished musician playing the violin, or an accomplished athlete playing basketball there are functional imaging studies that show lasting changes in the brain based on that learning and experience. Because neuroplasticity is not in itself unique to meditation, additional perspectives are needed to improve our understanding of the developmental consequences of meditation and allied contemplative practices and teachings. The brain is embedded in the rest of the body, just as our body is embedded in the rest of the world.

4.3 Psycho-Spiritual Development and Centrality of Self-Concept

There are many perspectives on self and its relation in spirituality. However, one's own conceptualization of who one is (self-concept) is pivotal for understanding psychological aspects of spiritual development (psycho-spiritual development), as shown in Figure 6. The dimension of psycho-spiritual development spans the entire human range, all the way to profound wisdom or enlightenment. The centrality of self-concept concerns the degree to which one's process of self-

identification asserts itself as a necessary frame of reference which other psychological processes must relate to. For example, centrality of self-concept is reflected in the degree to which a person values their own needs over anything else. Disorganization of one's self-concept (self-disorder) involves fragmentation in which the various facets of self-identity are in chaos, which can also entail a weak boundary between self and other. Self-disorder is exemplified by pathologically induced extreme states such as psychosis. In contrast, self-centeredness involves a conceptually governed disconnection of oneself from others. Transcendence of self-concept (self-transcendence) differs from disordered self-concept in that self is de-emphasized so that the needs of other people take precedence. Thus, decreasing self-centeredness fosters a more inclusive view of the world together with compassionate and spiritual engagement.

The curved path in Figure 6 indicates a typical path of an individual's change over time, though other transitions among states may be possible. An individual's traversal along this path may include progress (rightward movement) as well as regress (leftward movement). It is important to note that change along this path may occur at any of several time scales, from seconds or minutes to decades or longer. Within moment-to-moment variation in the flow of conscious experience, centrality of self-concept may either increase or decrease enough to make a difference in relating empathically with another person. Within a normal course of maturational development across the life-span, self-disorder occurs naturally in infancy, though centrality of self-concept normally strengthens during childhood and by adulthood reaches self-centeredness. Self-transcendence, if occurring ever, may tend to manifest later in life. Even without the enduring stability of self-transcendence that has been ascribed to completely realized (enlightened) beings, moments of self-transcendence may happen on occasion for people more generally.

Figure 6. Psycho-Spiritual States Depend on Psycho-Spiritual Development and Self-Concept. The horizontal axis depicts level of psycho-spiritual development. The vertical axis depicts

centrality of self-concept. The curved line traces a path along which a person may typically progress and regress through psycho-spiritual states. The left limb of this curve depicts disordering of one's self concept, the middle part of the curve (self-centeredness) represents maximal egocentrism, and the right limb depicts transcendence of self-concept. See text for discussion of movement along the curve.

4.4 Meditation Changes One's View of the World

Do meditation and spiritual experience influence how a person understands the world and their place in it? Each moment of experience is part of a flow in which momentum has been built from past moments in a trajectory leading into the upcoming moment. Worldview concerns this context of experience, and includes those attitudes, values and beliefs that carry us into the next moment. Worldview has been defined as a psychological construct that is comprised of one's values, attitudes and beliefs about human nature, will, cognition, behavior, interpersonal dimensions, truth, and the world and life (Koltko-Rivera, 2004). Participants in our study, adults in the United States who did not begin meditating as children but only later as adults, were asked if meditation affected their understanding of reality and their self-understanding, and if so to describe those effects (Grossenbacher & Parkin, 2006). All participants affirmed that meditation affected their understanding of reality. Most also affirmed that meditation affected their understanding of themselves. Decreased centrality of self-concept was exemplified by reports of being less preoccupied with their own thinking and therefore better able to listen to others, being receptive to what is being communicated, to the emotional needs of others, and to the emotional needs of themselves during an interaction. Altogether, many responses indicated an understanding of interpenetration of different mind streams (intersubjectivity), in which we all participate.

A person's actual lived experience may agree or conflict with their worldview. Experience that agrees with one's understanding of the self, the world, and reality is relatively easy to comprehend and remember. For this reason, it may be easiest to leave one's own worldview unexamined when either experience agrees with the worldview, or life is lived with such a fast mental speed that any mismatch between conceptualization of reality and actual feel of lived experience does not provoke deep reflection. Based on the evidence of their lived experience, a person may begin to question their own worldview. Reflecting on one's own worldview provides one way of engaging with a contemplative path. We see this again and again in perhaps an increasing number of people. As yet, there have been no neuroimaging studies on worldview in meditators, so this chapter does not address this topic at the physiological level.

5 Answers to Audience Questions

Question: Could you give more detail about what type of meditation you were doing research upon because as you know there is a large variety of meditation.

Answer: Together with colleagues including many graduate and undergraduate students at Naropa University, over the last few years we have developed methods that we and other researchers can use in order to obtain verbal reports from meditators in any number of different meditation styles or traditions. We have gone to great lengths to use English terms that are not specific to any particular tradition such as Soto Zen or Kagyu Tibetan meditation. Our methods use language that can be understood by people meditating in any of several dozen different traditions that we have sampled. Some people who have not been formally trained in an

established tradition of meditation may have a regular practice, for example, to stand in their garden quietly at sunset to be at peace with the world.

We are working on a definition of meditation that is based on the data that we have been collecting, rather than having started with an idea of what meditation is already in mind. We would rather collect data from numerous participants, and then based on those data distinguish among different kinds of meditation from a psychological point of view. This might ultimately result in determining that some styles actually are meditation and others are not meditation. Perhaps in five years we will have an answer to this question.

Question: You differentiate between three levels: divided mode, unified mode, and you separate unified mode into stillness and luminosity. How do these levels relate to the finding of a part of the brain that increases in thickness when people meditate a lot.

Answer: The distinction between divided and unified is a very helpful, though basic, way of understanding many of the things that happen in the human brain. We have parts that are in conflict with one another. Sigmund Freud made a life's work out of studying how neurotic and confused people are, having different parts disagreeing with each other. We see the same thing happening at the level of the brain where different neural circuits are each busy working on their respective specific content, but there is no coordination or temporal coherence of neural outputs among these circuits. With respect to contemplative development, unified mode may relate to some of the ideals that we hold as meditative stillness or equipoise. However, unified mode does not have to be still. There is space that accommodates everything, with room for experience of energy. We can think of the difference between stillness and luminosity in unified mode as a degree of arousal as to whether the system is rather quiet or whether there is more energy, and neither one is better than the other or more advanced. The change in cortical thickness provides clear evidence that when somebody invests their lifetime to pursue a path of meditation, this changes who they are at a physical level. For practitioners and people who have met advanced meditators, this should come as no surprise.

To summarize, meditation results in consciously noticing a greater range of experience. This shift, which may result from improvement in attention skills, may be a catalyst for adopting worldviews that are distinct from those held previously. These changes in awareness and worldview may contribute to developing greater capacity and motivation for communication with others. Through meditating, people come to recognize and embody open awareness and bodily experience becomes heightened, and subtler. Meditators can become more attuned to, and skillful with their emotional life with their thoughts and even with their capacities for attention and coherent brain activity. These effects of open awareness have a lasting impact on a person's life.

By the way, gamma coherence has been studied for over a decade, not just in humans, but also cats and monkeys and rabbits. This work started in looking at how animals, including people, move their bodies. Studies found that multisensory awareness, multi-sensory perception, vision, bodily sensation, and control of muscles that move our limbs can all act coherently together. Perhaps this helps explain why yoga, tai chi, walking meditation, and other contemplative practices that involve movement may be as effective as sitting meditation. In daily life, it helps to act consistently with our feelings of compassion and our sensitivity toward sentient beings.

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7 Authors' Biographies

Peter Grossenbacher: Through his scientific research work at England's University of Cambridge, the U.S. National Institute of Mental Health, and Naropa University in Colorado, Dr. Grossenbacher has broadened psychological science to more fully address human capacities of awareness. He has conducted brain imaging studies on conscious experience using positron emission tomography, electrophysiology, and functional magnetic resonance imagery. This work builds on his undergraduate training in cognitive science and mathematics (University of California at Berkeley) and doctoral training in experimental psychology and cognitive neuroscience (University of Oregon). His book, *Finding Consciousness in the Brain: A Neurocognitive Approach*, offers new insights into the brain's involvement in cognition, perception, and attention. As Chair of the Contemplative Psychology Department at Naropa University, he oversees an innovative curriculum melding scientific and contemplative modes of inquiry, and encouraging learners to come to know themselves more deeply through meditation. As Director of Naropa's Consciousness Laboratory, he leads research teams of graduate and undergraduate students exploring the contemplative varieties of spiritual and religious experience. His research has been covered by the *New York Times*, *Smithsonian Magazine*, and *Discover Magazine*, as well as numerous radio interviews and newspaper articles.

Although he was not present at the original conference presentation, Timothy Crespi has joined as coauthor for this chapter. Timothy Crespi completed a bachelor's degree at Naropa University with a double major in Contemplative Psychology and Environmental Studies. He has contributed as a student researcher in Naropa University's Consciousness Lab for a year and a half and has great interest in meditation, contemplative practice, wilderness therapy and consciousness research. He is continuing his education at Naropa University in the MA program in Transpersonal Counseling Psychology.