

self and consciousness in neuroscience, meditation, and philosophy

EVAN THOMPSON

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binocular rivalry. What we're asking about, to use the early Indian Buddhist terminology, is the contingency of visual consciousness on name-and-form: specifically, how a moment of visual awareness depends on the physical and psychological makeup of the perceiver. As we'll see, investigating binocular rivalry has proven especially fruitful for addressing this question.

# NOW YOU SEE IT, NOW YOU DON'T

One of the main goals of the neuroscience of consciousness is to discover the so-called "neural correlates of consciousness"—the neural processes that correlate directly with conscious experience, also known as the NCC.9 Neuroscientists distinguish between two main kinds of NCC. On the one hand, there are the brain activities that correlate directly with the level of consciousness—awake, asleep, dreaming, alert, drowsy, and so on. On the other hand, there are the brain activities that correlate directly with specific conscious experiences, such as the visual experience of the color red. Binocular rivalry is one of the main experimental paradigms scientists have used to hunt for neural correlates of consciousness in the second sense, in this case the neural correlates of specific visual experiences.

Binocular rivalry seems ideal for this quest because it seems to offer a way to differentiate between conscious and unconscious visual contents—"now you see it, now you don't"—at the level of the brain. In other words, it seems to offer a way to dissociate the neural activity corresponding directly to conscious visual perception from the neural activity associated with unconscious processing of the stimulus. Although the stimulus stays constant, the conscious perception changes dramatically every few seconds. What neuroscientists seek to uncover are the neural processes that correlate directly with one image being perceptually dominant (now you see it) versus the neural processes responsive to the same image when it's suppressed (now you don't).

Neuroscientist Nikos Logothetis, at the Max Planck Institute for Biological Cybernetics in Tübingen, Germany, pioneered this approach in the 1990s in a series of experiments with macaque monkeys.10 These animals have a visual system similar to ours, they experience binocular rivalry, and they can be trained to pull a lever when they see one image or the other. Logothetis and his colleagues recorded the firing of individual neurons in a number of visual brain areas while the monkey viewed a binocular rivalry display. These areas included the primary visual cortex (V1)—whose neurons are tuned to one eye or the other and respond to basic features of the visual world, such as contrast, orientation, motion, direction, and speed-and higher visual areas that respond to object categories, such as faces or houses. These scientists found that neural activity at early stages of the visual pathway closer to the retina was better correlated with the stimulus, regardless of what the animal indicated it was perceiving, whereas the proportion of neurons whose activity correlated with the animal's perception increased at later visual stages. Neural activity in the earliest visual cortical area, the primary visual cortex (V1), correlated almost entirely with the stimulus, independent of perception. Meanwhile, almost all the recorded neurons in the inferotemporal cortex (IT)—the last stage in the ventral visual pathway and an area crucial for object recognition-responded only to the dominant perceptual image. For example, neurons in IT sensitive to butterfly images but not sunburst images responded only when the animal indicated that it saw the butterfly and not the sunburst image presented to the other eye.

Other studies in humans have also shown that activity in later object-recognition areas of the ventral visual pathway reflects the reported perception in binocular rivalry. These human studies, however, also found strong correlations between the reported perception and activity in early visual areas, including V1 and the lateral geniculate nucleus, or LGN (a part of the thalamus that receives signals from the retina, sends connections to V1, and receives strong feedback connections from the cortex).

What these monkey and human studies indicate is that there's no single site in the brain correlated with reportable conscious visual perception. Put another way, the NCC for a specific visual experience of an object seems to consist of brain activities distributed over multiple areas, including both early visual areas sensitive to basic sensory qualities and higher visual areas sensitive to object categories, as well as frontal and parietal areas involved in voluntary attention. As Logothetis wrote in 1999, summarizing the results of his studies: "the findings to date already strongly suggest that visual awareness cannot be thought of as the end product of such a hierarchical series of processing stages. Instead it involves the entire visual pathway as well as frontal parietal areas, which are involved in higher cognitive processing. The activity of a significant minority of neurons reflects what is consciously seen even in the lowest levels we looked at, V1 and V2; it is only the proportion of active neurons that increases at higher levels in the pathway." 12

Given these findings, we can ask the following questions. If there's no single locus for the brain activity associated with conscious perception, is there something that links or holds together the widespread and distributed neural activities that occur during a moment of conscious perception? Does the back-and-forth shift from "now you see it" to "now you don't" correspond to shifting relations between multiple brain areas? Is it possible to track how these areas coordinate their activities when a "now you see it" moment occurs?

### WAVES OF CONSCIOUSNESS

The binocular rivalry demonstration Diego Cosmelli showed me in Paris was part of an experiment he had designed to address these questions. To find out what happens in the brain during the flow of alternating images, Cosmelli used the approach Francisco Varela called "neurophenomenology." Neurophenomenology combines the careful study of experience from within with investigations of the brain and behavior from without. It uses descriptions of direct experience to guide the study of the brain processes relevant to consciousness.

Cosmelli asked the participants in his experiment to explore and describe their experience with the binocular rivalry stimulus. Their descriptions indicated that their experience had an inherent ebb and flow like the rise and fall of ocean waves. Dominance periods for each image recurred in time, but the transitions between them happened in variable and shifting ways. Sometimes the transition from one image to the other began in the center of the field and moved outward; sometimes it began on one side, or from the top or the bottom, and then progressively took over the other image. Most participants claimed it was hard to give a stable description of how these transitions happened, because they arose in a different way each time. Yet everyone said they saw one image for a while and then the other image, no matter what they did or how much they tried to prevent it.

Cosmelli's question was whether we could follow these waves of consciousness in the brain. Does the brain activity during perceptual rivalry show corresponding patterns that recur in time but with variable transitions between them?

Taking our lead from the way experience flows through time means we need more refined methods to analyze brain activity than the ones neuroscientists often use. Scientists often simplify the binocular rivalry experience for experimental purposes by treating it as a clear-cut alternation between two otherwise static visual states—the perception of one image and then the other. The experimenter instructs the participant to indicate with a button press the moment when the perceptual switch happens; this report provides a fixed reference point in time for defining the average brain state when the participant sees one image and the average brain state when she no longer sees it. The experimenter then contrasts these average measures to see what's specific to the conscious perception of the image. This approach has provided a wealth of important findings about the basic properties of binocular rivalry and their basis in the brain.

If we don't simplify the binocular rivalry experience this way, but instead appreciate it as a flowing experience consisting of variable and recurrent visual fluctuations, then we can't assume there's such a thing as an "average transition" from one image to the other. Average

measures wipe out the variable aspects of a phenomenon. So assuming there's an average transition in binocular rivalry would prevent us from being able to take account of variations in how the whole experience unfolds in time and how these variations are reflected in brain activity.

Cosmelli and his colleagues in Varela's lab therefore developed a new statistical framework that considered as significant any neural activity that recurs in time, regardless of when it happens. This enabled them to follow the spontaneous flow of brain activity during binocular rivalry while they tracked neural patterns that occurred again and again, but never in precisely the same way.

These scientists also took advantage of the fact that stimuli like the expanding checkerboard rings—which moved outward from center to periphery at a rate of five times a second—will produce corresponding neural responses at the same frequency in the brain. The neural signals will go through an up-and-down cycle with peaks and troughs, like a pendulum swinging back and forth in what physics calls an oscillation, and the frequency of this so-called neural oscillation will match the expansion of the checkerboard rings. By looking at how these oscillating neural responses evolve, one can determine what distinctive features they acquire during conscious perception of the checkerboard image, compared to when that image is suppressed. To track these brain responses, Cosmelli and his colleagues used a neuroimaging technique called magnetoencephalography (MEG), which measures the magnetic fields produced by electrical activity in the brain.

What these scientists found was that neural responses oscillating with the same frequency as the checkerboard rings occurred at several distinct brain regions throughout the entire viewing period, but only during conscious perception of the checkerboard image did they become precisely synchronized. To visualize these "synchronous neural oscillations," think of the "wave" at a sporting event, where successive small groups of spectators stand and raise their arms at the same time and then sit down again. Each complete upand-down cycle is like an oscillation, and the phases of these oscillations—the points on these cycles where some people are on their way

up and other people are on their way down—have to be precisely coordinated. Similarly, Cosmelli and his colleagues found that during conscious perception, the neural responses located in different brain regions were oscillating in synchrony. More precisely, the phase of each neural response—where exactly it was in its oscillatory cycle—was in sync with the phases of the other neural responses. Neuroscientists call this phenomenon "neural phase synchrony." Thus, the NCC for the perception of the expanding checkerboard rings consisted of a large-scale pattern of neural phase synchrony occurring within and between many regions of the brain.

Other experimental results by Varela and his colleagues support this idea of a moment of reportable conscious perception being correlated with large-scale synchronous oscillations in the brain. Earlier in Varela's lab, before Cosmelli's experiment, Eugenio Rodriguez had shown that a large-scale pattern of neural synchrony correlates with the "now you see it" or "Aha!" moment when you suddenly see a face in what initially seemed to be meaningless shapes.14 Rodriguez used the electroencephalogram (EEG) to measure electrical activity at multiple sites on the scalp. Such activity reflects the underlying electrical activity in the cortex and shows complex patterns in different frequency ranges. In addition, the dominant frequency component changes according to the level of consciousness. For example, in the waking state, the so-called alpha rhythm (8-12 hertz or cycles per second) is the most prominent feature of the EEG, but fast rhythms in the beta (12-30 Hz) and gamma (30-80 Hz) frequency ranges are also strongly present, whereas in deep sleep, slow-frequency delta waves (0.5-4 Hz) are dominant. Rodriguez and Varela found that gamma oscillations, which are known to be associated with perceptual recognition and attention, occurred regardless of whether the ambiguous stimuli were seen as meaningless shapes or as faces, but at the "Aha!" moment when the stimuli were seen as faces, the gamma oscillations became synchronized at parietooccipital and fronto-temporal regions. In other words, the NCC for the "Aha!" moment consisted in the phase synchrony of the ongoing gamma oscillations. Building on this work, Lucia Melloni and Rodriguez later showed that a moment of reportable conscious perception

(compared to unconscious processing of the same stimuli) correlates with a large-scale pattern of synchronous oscillations in the gamma band. <sup>15</sup> Other studies have also confirmed that the neural correlates of reportable conscious perception consist of widespread patterns of neural synchrony. <sup>16</sup>

But what about the flow or continuum of such moments of conscious perception? The novelty of Cosmelli's study was that it addressed this question.

Cosmelli found that the back-and-forth rhythm from "now you see it" to "now you don't" corresponds to the formation and dissolution of a large-scale pattern of neural synchrony. Each time the perceptual transition from the face to the checkerboard rings started to happen, a new synchronous neural network was being formed, like the "wave" starting up at a hockey game. As a small group of fans starts to stand up and swing their arms, so, at the beginning of the perceptual transition, only a few cortical responses were synchronized. As the perceptual dominance of the checkerboard rings developed, the synchrony wave grew in scale, increasing both within occipital visual areas and between these and frontal cognitive areas. This large-scale synchrony pattern persisted for several seconds and coincided with full perceptual dominance of the checkerboard rings. As suppression of the image began, the wave in the brain subsided as the long-range synchronous activity fell apart, leaving isolated patches of local synchrony in occipital visual regions. During full suppression, few areas of synchrony remained and the brain pattern returned to the pretransition situation. Then the whole pattern of synchrony buildup began again, but in a slightly different way, a new wave in the stadium of the brain.

In summary, this study suggests that the alternation between the two images in binocular rivalry corresponds to waves of synchronous oscillations in the brain. The way conscious perception varies in time corresponds to the way neural synchrony varies in time. The arising of a new perceptual moment corresponds to the formation of a new pattern of neural synchrony, and the subsiding of this perceptual moment and its replacement by another one correspond to the dissolution of the synchrony pattern and its replacement by another

one. In both the perceptual experience and the brain activity, there's a rhythm of distinct moments that alternate repeatedly but never exactly in the same way. Waves of conscious perception correspond to waves of synchronous oscillations in the brain.

One more study, by Sam Doesburg and Lawrence Ward at the University of British Columbia, adds another level to these ideas. <sup>17</sup> Inspired by Cosmelli's study, these scientists used EEG to investigate the electrical brain rhythms occurring during binocular rivalry. They used the image of a butterfly and the image of a group of maple leaves. Doesburg and Ward found that the perceptual switch from one image to the other corresponded to the formation of a new pattern of gamma synchrony between cortical areas. But they also found that these fast synchronous oscillations (38–42 Hz) were connected to slower oscillations in the theta range (5–7 Hz). Roughly speaking, the fast gamma waves were superimposed on the slower theta waves, so that one slow wave carried many fast waves. The slow waves also affected the fast ones by varying their amplitude (height) and the way they synchronized. In these ways, the slower theta rhythms played a role in shaping the faster gamma synchrony patterns.

Doesburg and Ward propose that this coupling between fast and slow electrical brain rhythms supports discrete and successive moments of perceptual experience. On the one hand, the fast gamma synchrony integrates neural activities occurring at different brain regions and thus supports the binding together of sensory features (such as black and white shapes) into a coherent perception (such as seeing a face in profile). On the other hand, the slow theta rhythms define discrete and successive "frames" or moments of perception. According to this view, these fast and slow electrical brain rhythms structure the flow of conscious perception so that it consists of discrete and successive moments whose content can either stay the same—you continue to see the butterfly—or change every few hundred milliseconds-you see the butterfly change into the maple leaves. In short, the slow rhythms divide the sensory stream into discrete temporal units or moments of perception, while the fast rhythms bind the features discriminated within a given moment into a coherent perception. In this way, the slow rhythms define the

temporal context of perception (what you perceive as happening "now"), while the fast rhythms set the content (now you see a butterfly, now you see a bunch of maple leaves).

But is the flow of conscious perception really discrete, like the frames of a movie or a series of snapshots? Maybe this way of thinking about perception comes from relying too much on the unusual situation of binocular rivalry. Doesn't ordinary perception seem to be a continuous flow? How does this appearance of continuity come about, if perception is really discontinuous? As we'll see now, these questions were addressed long ago in Indian Buddhist philosophy in ways that parallel and cast new light on the current scientific discussions.

# MIND MOMENTS

"Consciousness, then, does not appear to itself chopped up in bits. Such words as 'chain' or 'train' do not describe it fitly as it presents itself in the first instance. It is nothing jointed; it flows. A 'river' or a 'stream' are the metaphors by which it is most naturally described. In talking of it hereafter, let us call it the stream of thought, of consciousness, or of subjective life." 18

So William James wrote in 1890, introducing the metaphor of the "stream of consciousness" into Western psychology. Over a thousand years before, the same image figured prominently in the Buddhist philosophical tradition known as the Abhidharma (Abhidharma in Pāli). There the Buddha is portrayed as saying: "The river never stops: there is no moment, no minute, no hour when the river stops: in the same way, the flux of thought." <sup>19</sup>

For both James and the Abhidharma, mental states don't arise in isolation from each other; rather, each state arises in dependence on preceding states and gives rise to succeeding ones, thus forming a mental stream or continuum. However, James and the Abhidharma have different views about the nature of the mental stream.

According to James, although the mental stream is always changing, we experience these changes as smooth and continuous, even across gaps or breaks. The gaps and changes in quality that we do feel or notice—for example, when we wake up from a deep sleep—don't undermine the feeling that our consciousness is continuous and whole. And the gaps and changes in quality that we don't notice aren't felt as interruptions because we're not aware of them.

The Abhidharma philosophers agree that the mental stream is always changing, but they argue that it appears to flow continuously only to the untrained observer. A deeper examination indicates that the stream of consciousness is made up of discontinuous and discrete moments of awareness. Whether the Abhidharma philosophers arrived at this view through inner observation or through logical analysis premised on an atomistic view of the mind, or some combination of both, is a matter of scholarly debate. In any case, they believed that discrete moments of awareness or "mind moments" can be identified, described, and catalogued; moreover, their duration is said to be measurable. As we'll see, the measures given in certain Abhidharma texts of how long these moments last bear comparison with modern scientific estimates of the duration of a moment of perception.

We first need some familiarity with the Abhidharma view of how the mind works.20 The Abhidharma builds on the basic Buddhist insight that each moment of awareness arises contingent upon a host of physical and mental processes, and in turn conditions the arising of the next moment of awareness. What we call "the mind" is a stream of momentary mental events, each of which can be analyzed into a number of basic constituents. Every mental event consists of a "primary awareness" together with various constituent "mental factors." The primary awareness belongs to one of the six types of awareness the Buddha delineates in the passage quoted above-visual awareness, auditory awareness, olfactory awareness, gustatory awareness, tactile awareness, and mental awareness (the awareness of a thought, emotion, memory, mental image, and so on). Vasubandhu, the fourth-century C.E. author of the classic work Treasury of Abhidharma, defines awareness as the impression or bare apprehension of something.21 We never experience bare apprehension, however, because every moment of consciousness always

arises in conjunction with a number of constituent mental factors. These factors qualify awareness by making it pleasant or unpleasant, focused or unfocused, calm or agitated, ethically wholesome or unwholesome, and so on.

The key insight is that every moment of consciousness not only apprehends a particular object, in the sense of a particular sensory or mental appearance, but also characterizes that object in various ways. More precisely, there's no way for consciousness to apprehend an object—for something to appear to consciousness—without that object or appearance being characterized by consciousness in some way or other. A moment of gustatory consciousness, for example, is never just an awareness of a particular taste and texture; it's an awareness that's attentive or distracted, that experiences the taste as pleasant or unpleasant, that categorizes the taste as the flavor of a mango, that discriminates the mango as ripe or unripe, and so on. In these and many other ways, every moment of consciousness is "about" or "directed toward" an object of experience.

The Abhidharma philosophers thus agree with Western phenomenologists, notably Edmund Husserl (1859–1938), that all consciousness is consciousness of something in one way or another. Phenomenologists call this feature of consciousness "intentionality." Western phenomenology and the Abhidharma agree that intentionality, being directed toward an object, belongs to the nature or being of consciousness; it isn't something that gets added to consciousness from the outside.

What's unique to the Abhidharma, however, is the way it analyzes the directedness of consciousness into the basic structure of primary awareness and constituent mental factors. Without the mental factors, consciousness couldn't grasp an object. In the words of a twentieth-century Tibetan teacher, Geshe Rabten: "A primary mind [primary awareness] is like a hand whereas the mental factors are like the individual fingers, the palm, and so forth. The character of a primary mind is thus determined by its constituent mental factors." According to this image, the occurrence of a moment of consciousness consists in the grasping of a particular object of awareness by means of the mental factors, and the flow of consciousness consists

in the picking up and putting down of successive objects by means of successive sets of mental factors.

The Abhidharma maps of the mind list over fifty distinct mental factors, specify their functions, and group the factors into various categories. These maps express the Abhidharma tendency to codify crucial phenomenological insights into elaborate theoretical systems. The core insight is that how we're aware deeply conditions what we're aware of, and that how we're aware can be ethically wholesome or unwholesome. The overall scheme is ethical and is meant to support Buddhist practice; to this end, the mental factors conditioning awareness are categorized according to whether they are positive (reduce suffering and increase well-being), negative (increase suffering), or neutral (neither positive nor negative in themselves). The lists and categories differ from one Abhidharma school to another, but the schools generally agree that there are at least five ethically neutral "ever-present" mental factors that are always functioning in every moment of consciousness: "contact," "feeling," "perception," "intention," and "attention." They perform the most rudimentary and essential cognitive functions, without which consciousness of an object would be impossible.

The first mental factor, "contact," consists in a three-way relationship between a sensory or mental object, the corresponding sensory or mental faculty, and the consciousness dependent upon these two elements. For example, a moment of visual consciousness arises in dependence on the faculty of vision and the presence of something visible; contact is the concurrence of these three elements. As the contemporary Buddhist scholar Bhikkhu Bodhi explains: "[Contact] is the mental factor by which consciousness mentally 'touches' the object that has appeared, thereby initiating the entire cognitive event."<sup>23</sup>

A moment of consciousness, however, never simply "touches" its object in some affectless way. On the contrary, it feels the object as pleasant, unpleasant, or neutral. ("Neutral" doesn't mean the absence of feeling; it means being neither pleasant nor unpleasant.) "Feeling" is the mental factor that performs this affective function. With sensory or mental contact, there occurs a basic affective quality or feeling tone, on the basis of which consciousness evaluates its object.

In addition to feeling its object, consciousness also discerns it. "Perception" is the mental factor that plays this role; it discriminates, discerns, or identifies the object by distinguishing it from other objects. Discernment is the basis for recognition, for being able to re-identify the object over time.

According to the Abhidharma, every moment of consciousness is also goal-directed, in the sense that it approaches its object with an intention or motivation. "Intention" (also translated as "volition") is the mental factor responsible for this goal-directed function. Normally we think and feel so rapidly and habitually that we don't see intention at work, but the Abhidharma maintains that it's always there, operating subliminally in each moment of consciousness. This factor is also what determines the ethical quality of consciousness, that is, whether the consciousness is wholesome (lessens suffering) or unwholesome (increases suffering).

Finally, "attention" is the mental factor that enables consciousness to orient toward its object, and to target and refer to it. It guides or binds all the other mental factors to the object of the primary awareness. In Bhikkhu Bodhi's words: "Attention is the mental factor responsible for the mind's advertence to the object, by virtue of which the object is made present to consciousness. Its characteristic is the conducting . . . of the associated mental states [factors] towards the object. Its function is to yoke the associated states [factors] to the object." Thus, according to the Abhidharma, there is no consciousness of a sensory or mental object without the mental orientation and reference that attention supplies.

The Abhidharma distinguishes attention from other factors that also focus consciousness on its object but that aren't present in every mental state. Two such factors in the Tibetan Abhidharma are "concentration" and "mindfulness." Concentration is the ability of the mind to focus exclusively or single-pointedly on the object; mindfulness is the ability to keep the object in focus without forgetting or floating away from it. Concentration differs from attention because it involves not just attending to an object but also sustaining that attention over time. Similarly, mindfulness involves more than attention because it retains the object in awareness from moment to moment,

repeatedly bringing it back to mind and preventing it from slipping away in forgetfulness. Concentration and mindfulness belong to the category of so-called "object-ascertaining" factors. These factors don't establish the basic attentional orientation to an object; they presuppose it. They function to make the object more determinate for consciousness, given that attention has targeted it. The object-ascertaining factors of concentration and mindfulness are vital to Buddhist meditation and are present only when the object is apprehended with some degree of clarity and sustained focus.

We can now appreciate that each discrete moment of consciousness is a structured cognitive event, involving at least a minimal level of feeling, discernment, attention, and intention. According to the Abhidharma, each of these momentary cognitive events arises and passes away in rapid succession. Our waking cognition of the world is thus discrete instead of a seamless flow. Contemporary visual science offers an analogous idea: although it seems as if we're seeing many things at one time, our eyes are actually darting about quickly from one thing to another and back again. Our impression of a seamless visual world doesn't come from taking in everything all at once or in a smooth progression; it comes from the rapid way our eyes sample the scene and from our knowing we can look anywhere we need to in order to get more information.<sup>25</sup> Similarly, from the Abhidharma perspective, although the flow of consciousness seems continuous. this appearance is like our impression of continuity while watching a movie; in reality, the arising and passing away of each cognitive event happens rapidly, like the high-speed sequence of movie frames.

Given this viewpoint, it's natural to wonder how much time it takes for a moment of consciousness to arise and subside. How long does a moment of consciousness last? Are mind moments measurable?

Although the Abhidharma texts do address these questions, the answers they give aren't straightforwardly observational, for they combine what look like empirical observations with what we would regard as metaphysical considerations. <sup>26</sup> Several texts estimate the length or duration of a moment of consciousness in ways that sound observational. For example, the *Treasury of Abhidharma* says, "there are sixty-five instants in the time it takes a healthy man to snap

his fingers," a measure that works out roughly to 1/65th of a second, or 15 milliseconds, for a mind moment.27 We also find statements reflecting views of the mind that seem far removed from direct experience. For example, the following statement occurs in the Pāli Theravada Abhidhamma: "in the time it takes for lightning to flash or the eyes to blink, billions of mind-moments can elapse."28 Furthermore, metaphysical problems arise for Buddhist philosophy from supposing that mental events have any kind of duration, no matter how short. If something endures unchanged for even a millisecond, then it seems to violate the cardinal Buddhist principle of impermanence—that everything is constantly changing, that nothing is static for any period of time, no matter how brief. In classical Indian Buddhist philosophy, this thought led from a conception of mind moments as first arising, then briefly performing their function, and then finally passing away (the position of the Sarvāstivāda school) to a conception of mind moments as instantaneous, flashing into and out of existence at one dimensionless instant of time (the position of the Sautrantika school).

If the classical Abhidharma philosophers were alive today, they might wonder whether experimental psychology and neuroscience would have anything to say about these questions. If we set aside abstract metaphysical issues about the nature of time—whether time is discrete and momentary, or continuous—is there any scientific evidence for measurable discrete moments of experience in the stream of consciousness?

# MIND THE GAP

In 1979, when I was sixteen, I took part in an experiment Francisco Varela devised to investigate whether perception is continuous or discrete. I'd never been to a neuroscience lab, and the prospect of seeing my own brain waves was enticing. Francisco and I set off from Sixth Avenue and 20th Street, where we lived at the Lindisfarne Association, to the New York University Brain Research Laboratories

at 550 First Avenue. I sat in a dark room with electrodes fixed to my scalp and watched two small lights flash on and off. My task was to say whether the lights were simultaneous or sequential, or whether there was one light moving from left to right.

It's well known in experimental psychology that there is a certain minimal window of time within which two successive events will be consistently perceived as happening at the same time. For example, if you're shown two successive lights with less than about 100 milliseconds between them, you'll see the lights as simultaneous. If the interval is slightly increased, you'll see one light in rapid motion. If the interval is further increased, you'll see the lights as sequential. These phenomena of "apparent simultaneity" and "apparent motion" have sometimes been interpreted as supporting the idea of a discrete "perceptual frame," according to which stimuli are grouped together and experienced as one event when they fall within a period of approximately 100 milliseconds.

If perception is discrete—if it unfolds as a succession of perceptual frames with a gap between each frame and the next one—then we can make the following prediction: whether two distinct events will be judged as simultaneous or sequential depends not just on the time interval between them but also on the relation between the timing of each event and the way perception falls into discrete and successive frames, that is, the ongoing process of perceptual framing. In particular, two events with the same time interval between them can be perceived as simultaneous on one occasion and as sequential on another occasion, depending on their temporal relationship to perceptual framing: if they fall within the same perceptual frame, they're experienced as simultaneous, but if they fall in different perceptual frames, they're experienced as sequential. In short, what you perceive as one event happening "now" depends not just on the objective time of things but on how you perceptually frame them.

It was precisely this idea that Francisco wanted to test. Already in his early years as a young scientist, Francisco's research was strongly motivated by a vision of the brain as a self-organizing system with its own complex internal rhythms. (Although popular today, this vision was a small minority view in the 1970s, when most scientists thought

of the brain as a sequential-processing computer.) These rhythms, he believed, bring forth meaningful moments of perception in a fluctuating and periodic way. Francisco was also intrigued by the parallels between the Abhidharma notion of mind moments and the neuroscience view of discrete perceptual frames created by the brain's self-generated rhythms. A month or so before my visit to the NYU Brain Research Lab, Francisco and I had talked about the Buddhist idea of mind moments and the gaps between them as we walked to the old Paragon Book Gallery on East 38th Street, where he bought a hard-to-find copy of Louis de la Vallée Poussin's classic French translation of Vasubandhu's *Treasury of Abhidharma*. It was only after the experiment that Francisco told me what he really wanted to do was measure a mind moment.

In the experiment, Francisco recorded the brain's ongoing EEG alpha rhythm and used it to trigger when the two lights flashed on and off. The hypothesis was that seeing the lights as either simultaneous or in apparent motion would depend on when they occurred in relation to the phase of the ongoing alpha rhythm. Like a surfer catching a wave, if the lights arrived at a certain point of the repeating alpha cycle, they would be seen as simultaneous, but if they missed the wave, they'd be seen as in apparent motion. In other words, presenting two flashes of light always with the same time interval between them, but at different phases of the alpha rhythm, would result in noticeably different perceptions.

The results supported the hypothesis: when the lights were presented at the positive peak of the alpha rhythm, they were almost always seen as in apparent motion, but when they were presented at the negative peak (the opposite phase), they were seen as simultaneous.<sup>29</sup> In the published study, a figure showed my visual performance along with that of two other participants (see the bar labeled "ET" in figure 4 of the original study). At an interval of 47 milliseconds between flashes, my discrimination between simultaneity and apparent motion was at a chance level, but there was a change in the probability of my perceiving the lights as simultaneous when they were presented at either the positive or the negative peak of my ongoing alpha rhythm.

Here's how Francisco and I described what we took to be the significance of this study in our 1991 book, *The Embodied Mind*:

Experiments such as these suggest that there is a natural parsing in the visual frame and that such framing is at least partially and locally related to the rhythm of one's brain in the range of duration of about 0.1–0.2 milliseconds at its minimum. Roughly stated, if the lights are presented at the beginning of the frame, the likelihood of seeing them occur simultaneously is much greater than if they are presented toward the end of the frame: when they are presented toward the end of the visual frame, the second light can fall, as it were, in the next frame. Everything that falls within a frame will be treated by the subject as if it were within one time span, one "now." 30

Unfortunately, these promising results have proved difficult to replicate, both by Francisco in a follow-up study and by other scientists today. Nevertheless, the experiment is widely cited as precisely the kind of experiment that would be needed to demonstrate definitively the discrete nature of perception; furthermore, new and more sophisticated studies are extending and deepening this line of research into the relationship between electrical brain rhythms and the discrete character of perceptual awareness. For example, recent experiments show that whether a visual stimulus is consciously detected or not depends on when it arrives in relation to the phases of the brain's ongoing alpha (8–12 Hz) and theta (5–7 Hz) rhythms. You're more likely to miss the stimulus when it occurs during the trough of an alpha wave; as the alpha wave crests, you're more likely to detect it.

Such findings support the idea that perception happens through successive periodic cycles instead of as one continuous process. Like a miniature version of the wake-sleep cycle, neural systems alternate from moment to moment between phases of optimal excitability, when they're most "awake" and responsive to incoming stimuli, and phases of strong inhibition, when they're "asleep" and least responsive. Moments of perception correspond to excitatory or "up" phases; moments of non-perception to inhibitory or "down" phases. A gap occurs between each "up" or "awake" moment of perception and the next one, so that what

seems to be a continuous stream of consciousness may actually be composed of discrete and episodic pulses of awareness.

This picture of a pulsing and gappy stream of consciousness may hold even when you're paying constant attention to something. It's well known that different aspects of attention, such as "alerting" (maintaining an alert state), "orienting" (turning attention toward a target), and "executive control" (monitoring and resolving conflicts in the presence of competing targets), are associated with different electrical brain rhythms.34 It's also well known that "sustained attention"-attending to an area and keeping your attention focused there—enhances your ability to detect targets presented in that area. Scientists often use the metaphor of the "spotlight" to describe how your attention can move around your field of vision and focus selectively on certain areas, so that you detect more efficiently what falls within the spotlight. Although this metaphor suggests that sustaining your attention at a location is like continuously shining a light there, recent studies have found that the way sustained attention enhances perception is discrete and periodic, as if the spotlight blinks on and off every 100-150 milliseconds like a strobe light.35

One study used targets presented at the level of light intensity at which individuals detected the target only 50 percent of the time (the so-called "individual luminance threshold"). When the targets were presented at attended versus nonattended locations—that is, when they were presented within the "spotlight" of attention—detection performance fluctuated over time along with the phase of the ongoing EEG theta oscillations occurring just before the stimulus presentation. In other words, when the ongoing theta rhythm reached a certain phase, a stimulus presented just afterward was more likely to catch the wave and be detected.

If attention samples information periodically, as such studies suggest, and if attention is trainable, as the scientific studies of meditation to be discussed later in this chapter indicate, then we can hypothesize that long-term meditation practice may increase the sampling rate of attention by tuning certain brain rhythms, specifically the theta oscillations associated with attention. I will come back to this idea later.

The recent studies of attention and perception I've been discussing reinforce another point Francisco liked to emphasize—that the brain activity preceding an event is crucial for determining the significance of that event for perception and action. We can't understand brain activity just by looking at the neural response after the stimulus arrives; we need to examine the ongoing activity prior to the stimulus, which sets up how the stimulus will be received. Put another way, the brain meets the stimulus on its own terms, so to comprehend any neural response we need to see it as emerging from the context of the brain's ongoing activity.

This insight motivated one of Francisco's last published studies.<sup>37</sup> With his Ph.D. student, Antoine Lutz, he used neurophenomenology to investigate the brain's ongoing activity in relation to conscious perception. They found that experientially distinct kinds of attentional states occurring prior to a moment of perception—states they called "steady readiness," "fragmented readiness," and "unreadiness"—were associated with distinct gamma frequency phase-synchrony patterns, and that these EEG patterns predicted both the subsequent brain activity during the perception and how subjectively stable and vivid the perception was reported as being.

The experimental findings I've been presenting are consistent with the Abhidharma view that the stream of consciousness consists of discrete and successive moments of awareness. The neuroscience findings also indicate that the immediately preceding moments of the stream of consciousness strongly influence the characteristics of the following ones.

But what about the duration of these moments of awareness? How do the Abhidharma measures and their scientific counterparts compare?

## MEASURING AWARENESS

As mentioned earlier, the Abhidharma measures that seem observational work out to around 10-20 milliseconds as the time it takes for

a minimal moment of awareness to occur. This estimate might seem remarkable from the perspective of cognitive science. It's significantly less than the 100–250 millisecond time periods usually given for a moment of reportable perceptual awareness, and it suggests that individuals may be able to discern events as fast as 10–20 milliseconds occurring in their own stream of consciousness. Is there any scientific evidence that speaks to these issues?

The short answer is yes. A recent study showed that some people can be aware of a target stimulus that's presented for only 17 milliseconds and followed immediately by another stimulus that masks it. 38 These individuals were "high achievers" compared to the others in the study who weren't reliably aware of such rapidly presented stimuli. In addition, recent scientific studies have shown that certain types of meditation improve attention in precisely measurable ways on a millisecond time scale, so you could start out as an "average achiever" and become a "high achiever" as a result of meditative mental training. Taken together, these findings suggest that being able to identify and describe discrete moments of awareness happening as fast as 10–20 milliseconds is by no means beyond the human mind, especially the mind trained in meditation. Thus the Abhidharma philosophers' estimates of roughly 15 milliseconds for an inwardly observable mind moment do not seem unreasonable.

There's a long answer, however, that's also worth giving. We need to take account of two key points that have emerged from recent scientific studies of perceptual awareness. First, determining whether someone is aware of a stimulus is a difficult matter. There's no single, definitive way of defining and assessing awareness; rather, there are multiple criteria and methods we can use. Second, awareness isn't the same for everyone; people differ in their awareness of target stimuli.

One obvious way of finding out whether you're aware of something is to ask you. According to this method, you're unaware when you sincerely report not having seen the target stimulus. Here the decisive factor is what you, the individual subject, report about your awareness, so the criterion of awareness is a "subjective criterion." This approach respects your first-person perspective and the unique

access you have to your experiences. But if your mental stream includes subliminal moments of awareness you're not able to report, then this kind of subjective criterion will miss them.

A different approach to finding out whether you're aware of something is to give you a forced-choice task, where you have to say either "yes" or "no" every time you are asked whether the stimulus was present. If you perform better than chance, then, according to this "objective criterion" of awareness, you're aware of the stimulus, even if you deny being able to see it. This approach can reveal moments of awareness you may not be able to report, but it provides very little, if any, information about what your experience is like for you.

Recent experiments using various subjective and objective criteria of awareness have shown that individuals differ in their awareness of target stimuli.39 For example, in the study I just mentioned, neuroscientist Luiz Pessoa and his postdoctoral researcher Remigiusz Szczepanowski used both objective and subjective criteria to investigate the visual awareness of rapidly presented emotional stimuli.40 The target stimulus was a photograph of a face with a fearful expression; it was presented for 17, 25, 33, or 41 milliseconds, and then immediately followed by another stimulus that served to "mask" the target. (This technique is called "backward masking.") The target plus the mask lasted 100 milliseconds. The participants had to indicate "fear" or "no fear." Calculating their performance how many times they got it right and how many times they got it wrong-provided a measure of their ability to detect the target stimulus, according to an objective criterion. The participants also had to rate their confidence in their answers on a 1-6 scale. The relationship between their confidence and their accuracy provided another measure of their awareness, according to a subjective criterion. The reasoning was that if the participants could not only detect the target better than chance but also make use of or rely on this ability, then higher confidence ratings should be linked with correct responses more often than with incorrect ones, and likewise, lower confidence ratings should be linked with incorrect responses more often than with correct ones. Szczepanowski and Pessoa found that all the participants could reliably tell when their responses were

correct for the 41- and 33-millisecond targets, and that some participants could also reliably tell when their responses were correct for the 25-millisecond targets. In addition, they found that nearly all the participants could reliably detect the 17-millisecond targets, but only a few participants—the "high achievers"—could also reliably tell when their responses were correct for these targets. In other words, for most participants, but not the "high achievers," there was a "dissociation" between the objective and subjective measures of awareness for the rapid targets. This suggests that although these participants could detect the targets, they had no inner access to or knowledge of their sensitivity.

An Abhidharma thinker could describe these findings as follows. When the participants detect the 17-millisecond targets, there's a primary visual awareness with the target as its focus, together with the "ever-present" mental factors of sensory "contact" with the target, a "feeling" tone in response to the fearful face, a "discernment" of the face as fearful (versus neutral or happy, the control conditions), an "attentional" orientation toward the target, and an "intention" or motivation to detect the target. In addition, for the "high achievers" who can reliably tell when their responses are correct for the 17-millisecond targets, further "object-ascertaining" mental factors are present, and these account for the cognitive access the participants have to their visual sensitivity. Such factors might include "determined attention," which achieves stability of focus, and "mindfulness," which retains or holds the target long enough in working memory so that the participants can evaluate the correctness of their responses.

At this point, we need to recall the distinction, introduced in chapter 1, between "phenomenal consciousness" and "access consciousness," that is, between consciousness in the sense of felt experience and consciousness in the sense of being accessible to thought, action guidance, and verbal report. One way to describe the "high achievers" is to say that they have some degree of cognitive access to their visual sensitivity to the 17-millisecond targets, whereas the other participants don't.

But now comes a difficult question: Should we think of the visual sensitivity to the 17-millisecond targets as a nonconscious process

that becomes phenomenally conscious only when it's cognitively accessible? Or should we think of the visual sensitivity itself as a phenomenally conscious process that's cognitively inaccessible to everyone except the "high achievers"?

According to the first way of thinking, only the "high achievers" are phenomenally conscious of the fast targets. According to the second way of thinking, nearly everyone has phenomenal consciousness of the fast targets, but only the "high achievers" are able to access and rely on it in their thinking, action guidance, and verbal reports.

What would the Abhidharma thinkers say? On the one hand, the distinction between "phenomenal consciousness" and "access consciousness" comes from recent Western philosophy of mind and shouldn't be projected onto Buddhist philosophy. On the other hand, according to the Abhidharma, we do need to differentiate between a basic moment of awareness and a person's ability to discern that awareness and its qualities, thereby enabling him to adjust his thought, speech, and action accordingly. So, from the Abhidharma perspective, it makes sense to say that any participant detecting the 17-millisecond target has at least a low-level phenomenal awareness of the target, but only some of the participants—the "high achievers"—have cognitive access to this awareness.

Now comes the crucial point of this long answer to our question about how the Abhidharma and cognitive science measures for mental events compare. If meditation has measurable effects on attention and awareness, including the electrical brain rhythms associated with them, then we have good reason to believe that the "dissociation zone" between objective and subjective measures of awareness could change as a result of meditation. In other words, we have good reason to believe that meditation could increase both one's sensitivity to the moment-to-moment flow of events (measured according to objective criteria of awareness) and one's inner cognitive access to that sensitivity, including one's ability to report and describe it (so that one also shows increased sensitivity according to subjective criteria of awareness). The supposition, in short, is that meditation can refine awareness measured according to both objective and subjective criteria, and that some of the accounts we read in the Abhidharma texts of

the rapid moment-to-moment flow of consciousness may have drawn upon this kind of refined awareness.

What, then, is the scientific evidence for meditation having these effects? And what does this evidence tell us about attention and perceptual awareness in the waking state?

### DON'T BLINK

"Millions of items of the outward order are present to my senses which never properly enter into my experience. Why? Because they have no *interest* for me. My experience is what I agree to attend to. Only those items which I notice shape my mind—without selective interest, experience is an utter chaos." Later in his Principles of Psychology, William James also adds: "For the moment, what we attend to is reality." <sup>142</sup>

If what we experience is what we attend to, and what we attend to is reality for us, then what we ignore or fail to notice will have no reality for us, even though it may affect us in all sorts of ways.

A compelling example from experimental psychology is the "attentional blink." When your task is to identify two visual targets presented within less than 500 milliseconds of each other in a rapid sequence of other visual stimuli, you'll often miss the second target even though you notice the first one. It's as if your attention blinks after you notice the first target, and the second one goes by in that instant. For the moment, what you attend to—the first target—is reality for you, and what you fail to notice immediately afterward—the second target—has no reality for you, even though it's there, affecting your visual system.

If meditation trains attention and awareness, does it affect the attentional blink? Can we use the attentional blink task as a way to assess the effects of meditation practice on attention and awareness?

The answer to both questions is yes, as neuroscientist Heleen Slagter showed in a series of experiments she conducted as a postdoctoral researcher in Richard Davidson's lab at the University of

Wisconsin-Madison. They investigated whether meditation practitioners would show improved performance on the attentional blink task after a three-month intensive retreat in Theravada Buddhist Vipassana or "insight" meditation. These retreats are conducted in silence, and individuals meditate for ten to twelve hours a day. Slagter and Davidson compared the performance of the practitioners on the attentional blink task before and after the retreat, and they also compared the performance of the practitioners with that of a control group of novices who were interested in meditation, took a one-hour Vipassanā meditation class, and were asked to practice for twenty minutes each day for a week before the experiment. After the three-month retreat, the attentional blink of the practitioners was significantly reduced, that is, the practitioners showed significantly improved detection of the second target (compared to the novice group, who also showed improvement). This improvement was also correlated in the practitioners (but not in the novices) with EEG measures showing more efficient brain responses to the first target.<sup>43</sup>

To appreciate these findings, we need to know more about Theravada Vipassanā meditation. This type of meditation involves practicing both "focused attention" and "open monitoring." These terms, although derived from traditional Buddhist meditative vocabularies, were recently coined by scientists and contemplative scholars in order to delineate the specific kinds of mental processes involved in various Buddhist and non-Buddhist meditation practices, ranging from Vipassanā to Yoga to Zen.44

In focused attention or concentration meditation, you direct your attention to a chosen object, such as the sensation of the breath entering and leaving your nostrils, and you keep your attention focused on that object from moment to moment. Inevitably your mind wanders as distracting thoughts and feelings arise. At some point, you notice your attention is no longer focused on the object. You're instructed simply to recognize that your mind has wandered, to release the distraction, and to return your attention to the object.

Repeated practice of focused attention meditation is said to develop a number of attentional skills. The first is a kind of watchfulness or vigilance that stays alert to distracting thoughts and feelings but without losing attentional focus. The second is the ability to disengage from distractions without getting caught up in them. The third is the ability to redirect the attention to its chosen focus. Developing these skills leads to attentional flexibility and an acute ability to catch your mind as it starts to wander. Eventually, focused attention practice leads to "one-pointed concentration"—the ability to sustain your attention effortlessly on the object for longer and longer periods of time.

In open monitoring meditation—or "open awareness" meditation, as I prefer to call it—you cultivate an "objectless" awareness, which doesn't focus on any explicit object but remains open and attentive to whatever arises in experience from moment to moment. One way to do this is to relax the focus on an explicit object in focused attention meditation and to emphasize instead the watchful awareness that notices thoughts and feelings as they arise from moment to moment. Eventually, you learn to let go of the object of attention and to rest simply in open awareness without any explicit attentional selection.

Open awareness meditation trains awareness of awareness, or what psychologists call meta-awareness. In open awareness meditation, meta-awareness takes the form of witnessing thoughts, emotions, and sensations as they arise from moment to moment, and observing their qualities. This style of practice leads to an acute sensitivity to implicit aspects of experience, such as the degree of vividness in awareness from moment to moment or the way that transitory thoughts and feelings typically capture attention and provoke more thoughts and habitual emotional reactions. One learns to see how habits of identifying with sensations, thoughts, emotions, and memories—in other words, with specific contents of awareness—create the sense of self.

Theravada Vipassanā meditation training usually begins with focused attention on the sensation of breathing; the practice then shifts to open awareness once some degree of attentional stability has been attained. In general terms, Vipassanā meditation cultivates a moment-to-moment awareness and clear comprehension of whatever arises in the field of experience. Such "mindfulness" is "non-reactive" in the sense that ideally one simply observes or witnesses

the coming and going of sensory and mental events without getting caught up in cognitive and emotional reactions to them. Put another way, Vipassanā cultivates an awareness that's "nongrasping" or "nonclinging" because one discerns whatever arises without holding onto it.

We can see these features of Vipassanā meditation reflected in the results of the attentional blink study. After three months of intensive Vipassanā practice, there was less mental "clinging" or "sticking" to the first target, so that attention was open and ready for the second target, making it easier to detect. This reduction in mental clinging or stickiness was reflected in the EEG brain waves, which showed that fewer attentional processes were devoted to the first target after intensive meditation training, making more attentional processes available for the second target. Furthermore, the individuals who showed the largest decrease over time in the neural activity they required to detect the first target also showed the greatest improvement in detecting the second target. Thus, a more efficient neural response to the first target seems to facilitate detecting the second one.

Recall the Abhidharma image of awareness as like a hand and the associated mental factors as like the fingers, so that the flow of consciousness consists in the picking up and putting down of successive objects by means of successive sets of mental factors. The attentional blink study suggests that Vipassanā meditation makes you better at quickly picking up a sensory object and then quickly letting go of it, so that you're ready for the next one.

But there's more. Earlier in this chapter I described how electrical brain rhythms in the theta frequency range (5-7 Hz) may define discrete and successive moments of perception and attentional sampling. Slagter and Davidson found that intensive Vipassanā meditation practice affected these theta rhythms in ways that were linked to improved performance on the attentional blink task.<sup>45</sup>

First, for both the practitioners and the novices, the neural oscillations in the theta frequency range "phase-locked" to the targets when the targets were consciously perceived. If you think of the incoming stimuli and the ongoing brain activity as making up a partner dance, then the brain stays in step with its stimulus partners by matching its activity at a certain frequency and phase to their arrival. Slagter and Davidson determined that whenever the targets were consciously seen, the brain had stayed in step with them by matching the phase of its theta oscillations to their occurrence.

Second, Slagter and Davidson found that in the practitioners, but not in the novices, the theta phase-locking to the second target increased following intensive meditation. The brain got better at staying in step with the second target. More precisely, there was a reduction in the variability of theta phase-locking from trial to trial, which is to say that the brain's matching of its theta waves to the second target became more precise and consistent. Furthermore, the individuals who showed the largest decrease in the neural processes required to detect the first target also showed the greatest increase in theta phase-locking to the second target. In this way, more efficient neural responses to the first target were linked to greater neural attunement to the second target. That is, individuals who required fewer resources to stay in step with the first target were also better at staying in step with the second one.

In these experiments, the participants were instructed not to meditate during the attentional blink task. So the results show that meditation can improve performance on attention-demanding tasks that don't require meditation. But what if the participants were asked to meditate while performing an attention-demanding task? How would treating the task as a meditation practice affect performance?

In another study, Slagter, Davidson, and Antoine Lutz asked the same\_meditation practitioners from the attentional blink study to perform an attention-demanding task as a focused attention meditation. 46 This was a standard selective attention auditory task called a "dichotic listening task." Two different auditory stimuli were presented simultaneously, one to each ear, and the participants were asked to attend to the tones presented to one ear, to press a button each time they detected an intermittent nonstandard tone in that ear, and to ignore the tones presented to the other ear. Performing this task as a focused attention meditation meant sustaining attention from moment to moment on the attended side in order to

detect the target tones, while also constantly monitoring the quality of this attention.

This study found that three months of intensive Vipassanā meditation increased the ability to sustain attention from moment to moment on the chosen object. Three measures indicated this increase in attentional stability. First, there was an increase in the phase-locking of theta oscillations to the target stimuli. Once again, the brain got better at staying in step with the targets, so that the consistency of its response increased from trial to trial. Second, there was a reduction in the amount of time it took to make a button press in response to the deviant tone, as well as a reduction in the variability of this reaction time, which is to say that the time it took to make the button press also became more consistent from trial to trial. Third, individuals who showed the greatest increase in theta phase-locking to the target also showed the largest decrease in their reaction time variability.

These studies using the attentional blink task and the dichotic listening task indicate that intensive Theravada Vipassanā meditation improves attention and affects brain processes related to attention. In the past five years, many other studies using other tasks and a wide range of meditation styles have shown that meditation improves perceptual sensitivity and strengthens the ability to sustain attention on a chosen object from moment to moment.<sup>47</sup>

One striking example used binocular rivalry to examine focused attention meditation. Olivia Carter and Jack Pettigrew found that Tibetan Buddhist monks were able to change the perceptual switching rate of the two competing images when they practiced focused attention meditation. <sup>48</sup> Half of the twenty-three monks reported that the amount of time one image remained dominant increased considerably while they practiced focused attention meditation as well as immediately after meditation. Three monks reported that the image remained completely stable with no switching for an entire five-minute period of focused attention meditation. In some cases, one of the two images was completely dominant; in other cases, the non-dominant image remained faintly or partly visible behind the dominant one, so that the conscious perception was of two superimposed

images. As Carter and Pettigrew observe, "These results contrast sharply with the reported observations of over 1000 meditationnaïve individuals tested previously."

Carter and Pettigrew conclude their report by "highlighting the synergistic potential for further exchange between practitioners of meditation and neuroscience in the common goal of understanding consciousness."<sup>50</sup> All of the studies I've been discussing should be seen in this light. Although many meditation studies emphasize mental training and its effects on the brain, these in particular also advance the neuroscience of consciousness.

Seen in this light, the finding that meditation in expert practitioners alters binocular rivalry points to the strong role that voluntary attention can play in affecting basic visual processes and thereby determining what we see. Earlier we saw that the neural correlates of conscious perception in binocular rivalry involve synchronous oscillations in the fast gamma band coupled to slower theta oscillations. Given Carter and Pettigrew's findings, it's reasonable to assume that focused attention meditation strongly affects these neural rhythms.

Similarly, the findings from Davidson's lab suggest that intensive Vipassanā meditation affects the ongoing brain activity that's specifically related to conscious perception. In both the attentional blink task and the dichotic listening task, Vipassanā meditation may increase the sampling rate of attention by fine-tuning the theta oscillations that shape the stream of sensory events into discrete moments of conscious perception.

Using these results, we can respond to an objection that might arise about the Abhidharma notion of mind moments. According to the Abhidharma philosophers, what appears as a uniform stream of consciousness to the untrained observer is really an articulated sequence of discrete moments of awareness. You might object, however, that if Vipassanā meditation changes experience and how the brain operates, then we have no right to assume that ordinary, premeditative consciousness is discrete and not uniform. Maybe premeditative consciousness is uniform and Vipassanā meditation makes it discrete. Given this possibility, it's unwarranted to project onto premeditative experience how experience seems after meditative training.

This objection is important. As a general policy, we must avoid the fallacy of projecting qualities from later trained experience onto earlier untrained experience. In the present case, however, we have independent data from psychology and neuroscience that ordinary perception and attention may be discrete, at least in certain respects or under certain conditions. We also have data about the electrical brain rhythms linked to these discrete functions. Given these findings, as well as the findings from the Vipassanā meditation studies on how meditation affects the same cognitive functions and electrical brain rhythms, it seems legitimate to conclude that meditation can sensitize you to discrete and gappy features of awareness you ordinarily overlook.

In summary, these neuroscience findings complement the Abhidharma view. Intensive Vipassanā meditation seems to refine the way the brain rhythmically organizes the sensory flow into discrete moments of perception, lessening the brain's tendency to get stuck on one momentary perception, thereby enabling the brain to be present to whatever arises in the next moment.

### BEYOND THE GAPS

If consciousness includes a gappy sequence of moments of awareness, what happens during the gaps? Does consciousness stop in each gap and then somehow start up again in the next moment? How do we account for continuity across the gaps? And what about more slowly changing background aspects of consciousness, such as being awake and alert versus daydreaming, falling asleep, dreaming, or being deeply asleep? How do these global levels of consciousness relate to the faster sequence of moments of perceptual awareness?

To deal with these questions from either the perspective of Buddhist philosophy or the perspective of neuroscience, we need to enlarge and enrich our conception of consciousness. Our last task in this chapter will be to trace this expansion in order to pave the way for the chapters to come. First, we need to be clear about what we're asking. We're not asking why we don't notice the gaps between moments of awareness. As philosopher Daniel Dennett writes, "The discontinuity of consciousness is striking because of the *apparent* continuity of consciousness.... Consciousness may in general be a gappy phenomenon, and as long as the temporal edges of the gaps are not positively perceived, there will be no sense of the gappiness of the 'stream' of consciousness." The Abhidharma philosophers would agree, but they would add that we can come to notice the temporal edges of the gaps when we've trained our minds in meditation, and in this way we can sense the gappiness in the stream of consciousness.

The questions asked above point to a different issue: how consciousness manages to function coherently, given that it's gappy. If consciousness is strictly momentary, in the sense that there's no consciousness whatsoever that persists during the gaps, then what accounts for its coherent functioning, not only from moment to moment but also across longer stretches of time? For example, what accounts for longer-lasting traits of consciousness, such as the attentional stability arising from meditation practice? Why don't the gaps between moments of awareness disrupt these continuities?

These questions arose early in the history of Indian Buddhist philosophy and eventually became pressing for the Abhidharma thinkers. Abhidharma theory dissects experience into discrete and momentary components, such as the six kinds of primary awareness and the various associated mental factors. The practical purpose of this dissection is to determine which unwholesome mental factors are present in a given moment of awareness, so that one can counteract them by cultivating the appropriate wholesome antidote factors in the next moment. For example, generosity is an antidote to greed; loving-kindness is an antidote to hatred; and intelligence is an antidote to delusion. For this practice to work, however, there must be some underlying continuity of mind, so that it makes sense to speak of latent unwholesome tendencies or dispositions and of transforming them into wholesome tendencies or dispositions. Hence, the relentless commitment to analyzing the stream of consciousness into a gappy sequence of discrete moments of awareness threatens to undermine the existential purpose of the whole Abhidharma framework. Buddhist scholar William Waldron calls this dilemma the "Abhidharma Problematic."  $^{52}$ 

One way Indian Buddhist philosophy dealt with this problem was by enlarging and enriching the Abhidharma notion of consciousness beyond the six modes of primary awareness. For example, the Theravada school distinguished between cognitively active forms of consciousness, such as waking perception, and a passive or inactive form of consciousness, which occurs in deep and dreamless sleep as well as in the gaps between moments of active consciousness. This passive consciousness is said to persist from the moment of conception until death, and thereby also to serve as the basis for the continuity of the individual. The Theravada school called this the "life-continuum" or "factor of existence" (bhavanga) consciousness. Bhikkhu Bodhi describes how it functions:

When an object impinges on a sense door, the bhavanga is arrested and an active cognitive process ensues for the purpose of cognizing the object. Immediately after the cognitive process is completed, again the bhavanga supervenes and continues until the next cognitive process arises. Arising and perishing at every moment during this passive phase of consciousness, the bhavanga flows on like a stream, without remaining static for two consecutive moments.<sup>53</sup>

A traditional image for this dynamic alternation between active and passive modes of consciousness is that of a spider resting at the center of its web and then moving quickly outward to catch its prey. As Buddhist scholar Rupert Gethin explains:

The web extends out in different directions and when one of the threads of the web is struck by an insect the spider in the middle stirs, and then runs out along the thread and bites into the insect to drink its juice. Similarly, when one of the senses is stimulated, the mind, like the spider, wakes up and adverts to the "door" of the particular sense in question. Like a spider running out along the thread, the mind is then said in due order to perceive the object, receive it, investigate it,

and establish its nature. Finally, again like our spider, the mind enjoys and savours the object.<sup>54</sup>

This image suggests that the passive life consciousness can accumulate tendencies or store elements from past experience by "digesting" what the active and cognitive modes of consciousness provide. Nevertheless, according to the Theravada theory, the life consciousness doesn't exist at exactly the same time as the cognitive awareness; it exists only in the gaps between active moments, when the active mode of awareness ceases. Active cognitive awareness and passive life consciousness alternate, turning on and off from moment to moment; in addition, the passive life consciousness exists from moment to moment in states where cognitive awareness is entirely absent, such as deep sleep. In these ways, there's a jutxaposition of active and passive modes of consciousness, but there's no superposition of the two modes at the same time. For this reason, the passive life consciousness seems to be a kind of "stopgap" consciousness, not a subliminal or base consciousness that supports the sensory and mental modes of awareness and provides for deeper and longerlasting continuities.55

Another Indian Buddhist school, however, the Yogācāra school, argued that there is an underlying and more continuous base consciousness.  $^{56}$  The Yogācāra philosophers called this the "store consciousness." Although the store consciousness too is momentary (because time in Buddhist metaphysics is momentary), it exists at all times, not just when the mind is cognitively active. As a base consciousness, it is always functioning subliminally. It serves as the support for the active forms of cognitive awareness in waking life and connects them to the more passive forms of awareness in dreams and deep sleep. Its material support is the energetic body, not any particular sense organ. As a "store," it contains "seeds" or latent dispositions that eventually "ripen" and manifest in the stream of active waking consciousness and in dreams. In this way, the store consciousness contains all the basic habits that are built up or accumulated throughout life (and from one lifetime to the next, in the Buddhist view).

The Yogācāra philosophers also added one more type of mental consciousness to their scheme-the preattentive "mind," also described as the "afflicted-mind consciousness." It can be thought of as an "ego consciousness" because it provides a preattentive sense of "I" or "Me." What makes this consciousness afflicted is that it habitually projects this "I" feeling onto the store consciousness, which it mistakenly takes to be a separate and independent self. In reality, however, the store consciousness isn't a separate and independent ego that's present in each experience and that functions as the owner of experience. Although it exists at every moment, it's constantly changing, like a flowing river, so nothing in it is wholly present from one moment to the next, and hence nothing in it could function as the owner of awareness. Thus the feeling that consciousness at its deepest level is somehow "I" or "mine" is based on a profound illusion. Because this illusion causes so much distress, the habitual ego consciousness is an afflicted consciousness.

Let me give an example to illustrate the Yogācāra view that our ego consciousness is fundamentally distorted. Take a moment of visual awareness such as seeing the blue sky on a crisp fall day. The ego consciousness makes this visual awareness feel as if it's "my" awareness and makes the blue sky seem the separate and independent object of "my" awareness. In this way, the ego consciousness projects a subject-object structure onto awareness. According to the Yogācāra philosophers, however, the blue sky isn't really a separate and independent object that's cognized by a separate and independent subject. Rather, there's one "impression" or "manifestation" 57 that has two sides or aspects—the outer-seeming aspect of the blue sky and the inner-seeming aspect of the visual awareness. What the ego consciousness does is to reify these two interdependent aspects into a separate subject and a separate object, but this is a cognitive distortion that falsifies the authentic character of the impression or manifestation as a phenomenal event.

Now take a memory of the blue sky, occurring a few months later on a gray winter day. The ego consciousness makes the memory appear as "mine" and thereby makes the present memory and the past perception seem to belong to one and the same "I" as their

.

owner. According to the Yogācāra view, however, there is no separate "I" that owns these experiences; there's only a stream of mind moments, with an earlier perception moment giving rise to a later memory moment (by way of the intervening active mind moments and the deeper passive continuity of the store consciousness). Moreover, the feeling of "I" will have undergone all sorts of changes between the time of the perception and the time of the memory, so the impression that one and the same "I" is wholly present from one experience to the next is an illusion.<sup>58</sup>

As we now can see, the notion of consciousness is multifaceted and has a variety of meanings we need to clarify.

On the one hand, "consciousness" can mean perceptual or cognitive awareness, that is, the kind of awareness that targets a specific object of perception, thought, or emotion, like a spider targeting its prey. This kind of consciousness is transitive—it takes an object, as when we talk about "seeing the blue sky," "tasting the coconut," "remembering the dream," "fearing the snake," and so on.

Western philosophers of mind call this "state consciousness." When we say someone is conscious of the face and not the checkerboard rings, or someone is conscious of the first visual target but not the second one, we're referring to particular states of transitive or object-directed consciousness that we specify in terms of their phenomenal contents (how things seem to the subject who's in the conscious state).

On the other hand, "consciousness" can mean life consciousness or sentience. This kind of consciousness is intransitive, as when we talk about being conscious versus being unconscious, or being sentient versus being insentient.

Western philosophers of mind call this "creature consciousness." Creature consciousness pertains to a whole subject of experience, not to the individual states of that subject. When we talk about waking consciousness versus dreaming consciousness, or about being awake and conscious versus being in a coma and unconscious, we're talking about global conditions or levels of awareness that pertain to the whole creature or sentient being as a subject of experience.

In addition, "consciousness" can mean self-consciousness. Self-consciousness comes in different forms, but what's important now is what we can call minimal self-consciousness, namely, the feeling that your consciousness belongs to you, that you are the subject of your awareness.

Notice, however, that this aspect of consciousness has to do with the sense of self—the feeling that this awareness here is yours. We can't assume that there really is a self that exists separately as the owner of this awareness. Whether there is a self is a further question not decided simply by the fact that we feel that there's a self. After all, as we've seen, according to the Yogācāra school, this feeling is a deep-seated cognitive and emotional distortion created by the ego consciousness (the afflicted-mind consciousness). We'll come back to this issue in the book's last chapter.

In this chapter, we've been focusing on consciousness in the sense of the perceptual awareness of an object. Our examples have been alternating images in binocular rivalry, two quickly flashing lights, rapidly presented visual targets in the attentional blink task, and standard and deviant tones in the dichotic listening task. What we're now in position to see, however, is that accounting for this kind of consciousness still leaves us needing to account for global conditions of awareness (waking, dreaming, and so on), the sentience or life consciousness they modulate, and the sense of self.

To my mind, the Yogācāra view represents an important innovation in Indian Buddhist thought because it recognizes the need to distinguish these global and more slowly changing background aspects of consciousness from more rapidly changing episodes of sensory and cognitive awareness. It also recognizes the need to account for how the sense of self arises and how it conditions the entire field of sensory and mental awareness. In these ways, the Yogācāra view (as well as other Indian yogic views to be discussed later) enables us to distinguish among the following aspects of consciousness: awareness and its global modulations across waking, dreaming, and deep sleep; the particular transitory contents of awareness (what we're aware of from moment to moment); and ways of experiencing certain contents of awareness as "I-Me-Mine."

Interestingly, we can trace an analogous line of thought in the neuroscience of consciousness. Binocular rivalry seems to give us a way to dissociate the neural activity corresponding directly to conscious vision from the neural activity associated with unconscious processing of the same stimulus. One of the working assumptions in the neuroscience of consciousness is that if we could find the neural correlates of consciousness for a particular sensory experience, such as the visual perception of a face, this finding might generalize to other sorts of conscious experiences. Put another way, if we could determine what the brain does when it makes an unconscious visual content into a conscious one—as it does in binocular rivalry—then we might be able to determine what makes a content conscious for any sensory modality.

But there's a limitation to this way of thinking. Although binocular rivalry consists in the alternation between one and the same visual content being consciously seen and not seen, this alternation always takes place within the total field of a subject's conscious awareness. In other words, binocular rivalry doesn't give us a contrast between the presence of consciousness and the absence of consciousness; it gives us a contrast between the presence of a particular visual content within consciousness and the absence of that content from consciousness. When you're in a binocular rivalry setup, you're awake with a coherent field of awareness, and you report the coming and going of a particular content within that field. Your consciousness as such, however, never disappears; on the contrary, the experimental setup depends precisely on your being conscious the entire time and being able to report the changing contents of your awareness.

You might think that neuroscience could build up to an explanation of the total field of awareness by putting together all the neural correlates of all the contents of consciousness at a particular time. The thought is that there are neural correlates for the sights you see, the sounds you hear, the odors you smell, the body you feel as yours, and so on, and that binding them all together in the right way would compose your total field of awareness. The philosopher John Searle calls this the "building block model" of consciousness. 60 The assumption is that consciousness is made up of a whole bunch

of individual experiences that are somehow bound together from moment to moment. Searle points out the problem with this: "Given that a subject is conscious, his consciousness will be modified by having a visual experience, but it does not follow that the consciousness is made up of various building blocks of which the visual experience is just one."

Searle contrasts the building block model with what he calls the "unified field model." According to this model, the neural correlates of individual conscious states aren't sufficient for those states, because those states presuppose that the subject is already conscious with a field of awareness. Any given conscious experience-such as seeing one of two images in binocular rivalry, or detecting the first target and then the second one in the attentional blink task-is a modulation of the already present field of awareness. In Searle's words: "Conscious experiences come in unified fields. In order to have a visual experience, a subject has to be conscious already, and the experience is a modification of the field."62 Thus, instead of trying to find the neural correlates for individual conscious experiences, the unified field approach investigates the neural basis for the whole field of awareness, including what happens in the brain and body as that field changes within and across such global states as waking, dreaming, and deep sleep.

We thus arrive by another route at essentially the same distinction discussed earlier—between being conscious in the sense of having transitory moments of object-directed awareness and being conscious in the sense of being a conscious creature with a persisting field of awareness that changes across waking and sleeping and is ordinarily permeated with a sense of self.

In the chapters to come, we'll focus mainly on consciousness as the total field of awareness and explore how the field of awareness and the sense of self change as we move from waking into dreaming and deep sleep. Our next task, however, is to take up the issue of pure awareness and its relationship to the brain.