CHAPTER FIVE

Where Neurocognition Meets the Master: Attention and Metacognition in Zen

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> To follow the lead of Nietzsche, James, and Jung, if the higher spiritual traditions of humanity might actually refer to something important . . . then some sort of account of how they could occur as an expression of the structure of the human mind will be necessary.
>
> —H.T. Hunt, *On the Nature of Consciousness*

A Zen Story

In a classic Zen story, retold by Kapleau, a man approached Ikkyu, a Zen master, and asked for the highest wisdom.

> Ikkyu immediately took his brush and wrote the word "Attention."
> "Is that all?" asked the man. "Will you not add something more?"
> Ikkyu then wrote twice running: "Attention. Attention."
> "Well, remarked the man rather irritably, "I really don't see much depth or subtlety in what you have just written."
> Then Ikkyu wrote the same word three times running: "Attention. Attention. Attention." (1965, pp. 10–11)

As this story suggests, in Zen Buddhism, the systematic training of attention is itself spiritual practice and a path to wisdom (see, e.g., Aitken 1982; Austin 1998; Cleary 1995; Kapleau 1965; Novak 1990; Rani and Rao 1986; Walsh and Vaughn 1993). Zen teaches that through the diligent practice of zazen(Zen sitting meditation), practitioners: settle the body and the mind (Aitken 1982); cultivate present-centered awareness, or "mindfulness" (Hanh 1976); observe the "habits" of mind and, ultimately, gain insight into the "true nature of being" (Aitken 1982; Hanh 1998; Okumura 1985;

Suzuki 1970). Although numerous religious and meditative traditions consider the training of attention an important aspect of spiritual practice, nowhere is attention more central than in Zen Buddhism (see, e.g., Austin 1998; Rani and Rao 1998; Zaleski and Kaufman 1997). Dogen Kigen Zenji, one of the pioneers of Zen in Japan, goes so far as to say "Zazen is itself enlightenment" (cited by Aitken 1982, p. 14).

Within Buddhism, there are two perspectives on *how* attention is "trained" through meditative practice. In one, the development of attention is treated as "the training of good habits." It is improved in the same way a muscle is strengthened in weight training so that it can then perform harder and longer work without tiring (Varela et al. 1991, p. 24; Wallace 1991). The other perspective is that the ability to sustain attention is part of the basic nature of the human mind, but that this "true mind" has been obscured by unnecessary mental activity and prior conditioning (e.g., Aitken 1982). Thus, rather than developing new attention skills, zazen gradually eliminates these unnecessary obscuring habits of the mind. These perspectives are not necessarily mutually exclusive. Rather, they may reveal a developmental process in zazen; just as one must rehabilitate a muscle that has atrophied from underuse, so may the disciplined "practice" of sustained attention in zazen yield progressively deeper insights into the nature of mind and the human condition (see, especially, Cleary 1995; Varela et al. 1991).

Chapter Overview

In this chapter, we explore the "training" of attention in the Zen Buddhist practice of sitting meditation (zazen) from the perspectives of cognitive psychology and cognitive neuroscience. In doing so, we integrate three propositions:

1. *zazen* cultivates present-centered awareness or *sustained selective attention* to one's moment-by-moment experience;
2. the practice of sustained selective attention in *zazen* interacts with executive processes in order to *regulate* attention;
3. as the ability to *sustain* present-centered awareness increases, the need for attentional regulation decreases, and *more cognitive resources* are available for "simply noticing" whatever occurs in one's moment-by-moment experience.

The essence of our argument is as follows. Attention serves to augment activity within specific areas of the brain that are required to carry out particular cognitive functions. This increased activity is what allows us to focus on a target and to ignore competing distractions (Edelman 1989; Posner and Rothbart 1991; LaBerge 1995). Attention is a limited commodity, meaning that if our attentional resources are consumed, performance will suffer. What consumes attentional resources? Selecting *in* what to attend to, selecting *out* what to ignore, maintaining arousal and interest over time, and monitoring attention to ensure that we have not been distracted and that the selected target is still being attended to.

Through the regular practice of zazen, as the mind settles and becomes less distractible, one becomes better able to sustain attention in the present moment (e.g., on the breath).[1] As fewer attentional resources are required to "regulate" attention—to continually return the attention to the breath when it has been distracted—more attentional resources are available to attend to experiences arising in the present moment, including, ironically, the same thoughts, feelings, memories, sensations that would have distracted us previously. The difference is that one simply observes these events dispassionately as they arise and fall away or, as Cheri Huber (2003) says, one "notices," "accepts," "embraces," and "lets go." With a reduced need to regulate attention, one's attentional capacity is devoted to present experience. One can "notice" more aspects of experience as they occur without being distracted by reactions, judgments, or internal commentaries on that experience (i.e., without being drawn away from the present moment). This experience, known in the Buddhist literature as "sarana" or freedom from conditioning (Aitken 1982), has also been termed "bare attention" (Suzuki 1962) or the "beginner's mind" (Suzuki 1970).

We begin with a background discussion of attention from the perspective of cognitive psychology and cognitive neuroscience. We then endeavor to consider zazen within this theoretical and empirical framework. Finally, we consider some of the implications of our approach, including implications for cognitive neuroscience and Western approaches to Zen.

What is Attention?

> Everyone knows what attention is. It is the taking possession by the mind, in clear and vivid form, of one out of what seem several simultaneously possible objects or trains of thought. Focalization, concentration of consciousness are of its essence. It implies withdrawal from some things in order to deal effectively with others.
>
> —William James, *The Principles of Psychology*

Muriel Brown noted as early as 1930, and it still true today: William James likely did not have scientists in mind when he said, "Everyone knows what attention is." Most people do have a sense of what attention is; for example, when we tell someone to "pay attention," or "focus" on what they are doing, or notice what is going on. Also, we are quite aware of attention when there is a failure to attend and we miss important information such as someone's name or the proper exit off the highway. However, attention has been difficult to scientifically define and study. Defining attention is a challenge because although attention seems to be one unitary function, it is more likely a collection of complex and interrelated processes (see Parasuraman, 1998; Posner and Boies 1971; van Zomeren and Brouwer 1994).

Attention as a Selective Mechanism

We are under constant bombardment from external sensory stimulation and internal processing of events such as thoughts, memories, and emotions. Because of computational limitations in the nervous system (see Neibur and Koch 1998), there is a limit to how much information we can process at any given time. Because we cannot process everything in parallel, we need a cognitive mechanism that allows us to select relevant information and ignore irrelevant information. Thus, attention provides a "selective" mechanism to help us handle this information "bottleneck" (Broadbent 1958).For example, if your intention (goal) is to listen to an important lecture and the people behind you are talking, you must make a "selection." What you select will be influenced by your intentions (top–down or conceptually driven processing) and by characteristics of the stimulus event (bottom–up or data-driven processing). Thus, even if your intention is to follow the lecture (top–down process), you may be compelled to attend to the conversation if it is especially loud (bottom–up process) (Solso 2001).

Attention may be viewed as a mental resource that is both limited in amount ("capacity") and flexible (see, especially, Kahneman 1973; Lavie and Fox 2000). In the lecture example, if the couple behind you is discussing something of interest to you, you may allocate some attention to listening in on their conversation while also continuing to listen to the speaker. Psychologists refer to this as "dividing" attention (see Hirst 1986; Spelke et al. 1976). Attending to multiple sources of information in this way can be accomplished without compromising comprehension, as long as one's entire attentional capacity has not been exceeded. On the other hand, if the lecture is especially complex and requires a great deal of concentration, more attentional capacity is consumed (Kahneman 1973). You would likely not have sufficient capacity to also follow the conversation. In fact, you might have to allocate some attention to actively ignoring the conversation so as not to be distracted from the lecture. If the combination of listening to the lecture and ignoring the conversation requires more attentional capacity than is available, your understanding of the lecture will be compromised. In short, once attentional capacity has been exceeded, performance suffers.

Sustaining Attention (Vigilance)

> As interest is sustained, so will attention be maintained.
> —William James, paraphrased in *Attentional Processing*

Even without distraction from a nearby conversation, you may not be able to sustain your attention to the lecture, especially if it is long or your motivation, interest, or arousal wanes. Your ability to maintain attention over time is related to your level of arousal, which is influenced by many factors, including interest (James 1890; LaBerge 1995), motivation (LaBerge 1995), stress-induced mental fatigue (Kaplan 1987), even circadian rhythms and sleep debt (Dement 1999; Monk 1991). In particular, it appears that low levels of arousal impact vigilance performance by limiting the availability of attentional resources (Humphreys and Revelle 1984; Matthews, et al. 1990). In other words, if you are not sufficiently motivated to pay attention to the lecture, distraction is likely and more attentional resources will be needed to select (and re-select) the lecture. With fewer attentional resources to sustain attention on the lecture, comprehension will likely suffer (Duffy 1962; Parasuraman et al. 1998, p. 233).

In our coming discussion of attention and meditation, we build on the assumption that attention is a mental resource with a limited capacity and focus on two aspects of attention that consume this capacity. As mentioned previously, due to the limits of our information processing resources, *selectivity* of attention is essential (Desimone and Duncan 1995). Once a target is selected, it is *sustained* attention (vigilance) that enables us to maintain goal-directed behavior over time (see Robbins 1998).

Cognitive–Behavioral Research on Selective Attention

In *selective attention* tasks, participants are asked to select and focus on what is relevant (a target) and ignore what is irrelevant (distractors). In a classic selective attention study by Treisman and Gelade (1980), subjects were presented with one blue X (target) among few or many distractors (red Os and blue or red Xs). Subjects were slower to locate the target in the presence of many distractors. Also, subjects were less accurate in selecting a target in the presence of distractors and performance declined further with the addition of more distracting information (Treisman and Gelade 1980). These findings indicate that irrelevant information is processed and consumes attentional resources that would otherwise be directed to processing the target.

What is distracting about irrelevant information? Irrelevant information (distractors) may pull our attention away from what we were intending to focus on, as discussed in the lecture example. However, distractors compete for our attention even when we are successful in selecting the appropriate target. Steven Tipper(1985) was one of the first to systematically study the effects of distractors on behavior. In his classic study, he presented participants with a pair of trials. In the first trial, the prime trial, subjects were presented with outline drawings of two objects and asked to name the target. The target object was outlined in green and the distractor in red. For example, for a green dog and a red cup, the subject should ignore the distractor (cup) and name as the target "dog." The second trial, called the probe, presented either two new stimuli (control condition) or re-presented the distractor (cup) as a target. In this case, the former distractor (cup outlined in red) was now presented as a target (cup outlined in green). A new stimulus, umbrella, was presented as a distractor (outlined in red). Tipper found that subjects were slower to respond to the cup in the probe trial compared to the control condition in which the target was not previously presented as a distractor. He concluded that although selection of the dog in the prime trial was accurate, processing of the distractor (cup) also occurred and had a carry-over effect on the next trial when the cup was re-presented as the target.

More recently, Nilli Lavie and her colleagues (Lavie and Cox 1997; Lavie and Fox 2000) have demonstrated that the processing of irrelevant information depends upon how much attentional capacity is required to select the target. Subjects were presented with prime and probe displays. For the prime, subjects had to decide which of three possible target letters was presented in one of six possible locations in the center row of the display while ignoring the peripheral distractor. Figure 5.1 illustrates this procedure.

Perceptual load was manipulated in the prime trial by adding nontargets in the other center row locations. This should increase the amount of

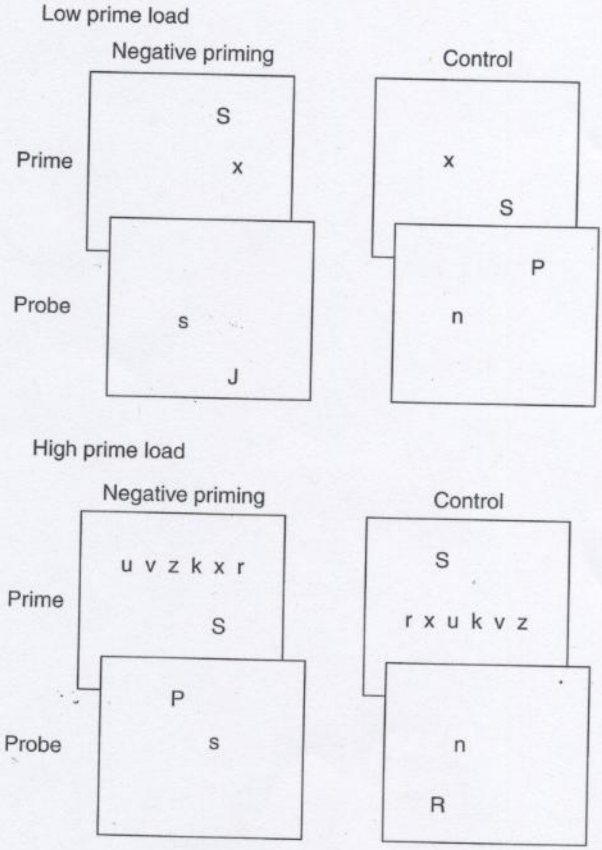

Figure 5.1 An example of the experimental procedure employed by Lavie and Fox (2000).

attention required to select the target because more items must be selected out; thus, more of the available capacity is consumed. On a relevant probe display, the distractor was re-presented as the target. They found that when the perceptual load was low (few nontargets), responses to the distractor as a target were slowed, meaning that the distractor was processed in the prime trial. When perceptual load was high (with five nontargets in the prime display), reaction times were *not* slowed when the distractor became the target, meaning that the distractor was *not* processed in the prime trial. These results suggest that when one is presented with one target and one distractor, little attentional capacity is needed to process the target and the remaining attentional capacity allows processing of the distractor. However, when there are many targets, attentional resources are devoted to processing the targets and little capacity remains to process the distractor (see, especially, Lavie and Fox 2000).

Taken together, the studies described above demonstrate that nontarget and distracting information compete with target information for attentional resources (Lavie and Fox 2000; Tipper 1985; Treisman and Gelade 1980). Of particular importance to our later discussion of attention and meditation, this research suggests that when a target task is simple, attentional capacity demands are low and it is available to process irrelevant information, leading to interference and perhaps distraction.

"Divided attention" tasks offer another way to investigate capacity limitations of attention. These tasks require participants to attend to two (or more) target tasks at the same time. Typically, one task is defined as the primary task and the other as the secondary task. The question is whether performance on the primary task is affected by the introduction of the secondary task.

Johnston and Heinz's (1975, 1978) research shows that the process of *selecting* a target "consumes" attentional capacity, and more capacity is consumed when the process of selection requires more initial processing. Similarly, if one or more of the tasks is novel or complex, more attentional capacity is consumed. In either case, if attentional capacity is exceeded, performance will be compromised (also see Lavie and Fox 2000; Spelke et al. 1976). However, with practice, participants are often able to "automatize" a task (or tasks), thereby "freeing capacity" and thus improving performance (also see Hirst et al. 1980; Schneider and Shiffrin 1977; Shiffrin and Schneider 1977). Automatizing a task can be beneficial, for example, when it provides a mental shortcut. LaBerge (1975) provides a helpful description of this process:

> For example, imagine learning the name of a completely unfamiliar letter. This is much like learning the name that goes with the face of a person recently met. When presented again with the visual stimulus, one recalls a time-and-place episode which subsequently produces the appropriate response. With further practice, the name emerges almost at the same time as the episode. This "short-circuiting" is represented by the formation of a direct line between the visual and name codes.

> The process still requires attention . . . As more and more practice accumulates, the direct link becomes automatic. (Mandler 1954, p. 52; cited by Solso et al. 2005, pp. 96–97)

Such mental shortcuts are especially helpful for procedural tasks like driving a car, playing a musical instrument, or engaging in an athletic pursuit. That is, unless one has automatized the task or skill inaccurately. Anyone who has attempted to remove the "uhs" and "ums" from his or her professional presentations or to change an ineffective golf swing knows how difficult it is to "deautomatize" a complex skill (Deikman 1982). Deautomatizing these skills would require a shift from divided attention to "focused attention" (Treisman and Gelade 1980) or from "automatic processing" to "controlled processing" (Schneider and Shiffrin 1977; Shiffrin and Schneider 1977). In any case, returning one's awareness and cognitive control to a task that has become habitual or automatic requires and consumes considerable attentional resources. This process is readily seen in the classic Stroop Effect, first demonstrated by J.R. Stroop in 1935. In a Stroop task, subjects are asked to name the color of the ink that stimuli are printed in. The Stroop Effect is the persistent finding that when stimuli are simple patches of color, subjects are much faster to name the color of the ink of each patch than when stimuli are color words printed in a different color (e.g., the word "red" printed in blue). The Stroop Effect presumably occurs because of a response conflict between naming the color of the ink, which requires selective attention to a particular feature of the stimuli, and the automatic process of reading (also see MacLeod 1997).

Cognitive–Behavioral Research on Sustained Attention

Selection is an obvious and important aspect of attention. What happens when we must not only select, but also *maintain* that selection for a period of time? The prolonged attention to a task is called sustained attention, or vigilance (see LaBerge 1995). Comparatively little research has examined sustained attention.

Mackworth's Clock Test (Mackworth 1950) has been used to study sustained attention. In this task, participants watch a clock for two hours and monitor the jumps of the second hand. The participant's task is to respond when the second hand jumps two rather than only one second, a variation which occurs only 3–5 percent of the time and in an unpredictable manner. Typical findings are that the major decrement in performance is within the first 15 minutes, with a more gradual decline thereafter (Teichner 1974) (see Parasuraman, et al. 1998, for a review of related research).

David LaBerge (1995) has a somewhat different conceptualization of sustained attention. He uses "preparatory" attention to describe goal-directed attention sustained over a period of seconds or longer. In other words, preparatory attention allows us to maintain attention with an associated expectation in mind. For example, while stopping at a red light, you may sustain your attention on the light in preparation for it to turn green. In the lecture/conversation example described earlier, you could use "preparatory attention" to sustain your focus on the lecture because you expect to hear something new or useful to you. LaBerge points out that "maintenance" attention is very different, and has hardly been studied. Maintenance attention is used when observing an object with no immediate goal in mind, such as when watching waves crashing in the ocean, observing a bee pollinating a flower, or listening to music. The difference is that whereas preparatory attention is sustained attention to "what will be," maintenance attention is sustained attention to "what is"; it is attending to an object for the sake of the moment, without consideration of upcoming events. This conceptualization is similar to "receptive awareness" or "presence-openness" in the meditation literature (see Hunt 1995, chapter 11).

The Interplay of Attention and Metacognition in the Regulation of Attention

The varieties of attention discussed above are important to the selection and maintenance of goal-directed behavior (Parasuraman 1998). However, attention also interacts with intentionality, self-monitoring, and self-regulation—higher-order central executive and metacognitive processes which also consume cognitive resources (see, especially, Baars 1988, 1997; Baddeley 1987; Flavell 1979; Nelson and Narens 1990). One must set a goal or intention: understanding a written passage, for example. One must choose an attentional strategy to help achieve the goal, such as choosing to return one's attention to the beginning of a sentence in order to better understand the meaning of the sentence. Also, one must monitor his or her progress or outcomes to ensure the intention is fulfilled.

We suggest that in zazen, especially in early meditative practice, there is an interplay between attention and three important executive or metacognitive processes: *intentionality* (setting a goal or intention); *self-monitoring* (monitoring one's behavior in relation to that intention); and *self-regulation* (choosing a response that moves toward fulfilling one's intention) (see, especially, Metcalfe and Shimamura 1994; Nelson and Narens 1990; Umitla 1988; Underwood 1997).

Neural Mechanisms of Attention and Executive Functions

What is the evidence that the attentional and executive systems are interdependent, yet dissociable? Studies involving brain damage, neuroimaging, such as positron emission tomography (PET) in humans, as well as single-unit recordings in animals have helped determine which brain regions are more or less involved in various aspects of attentional processing (Corbetta 1998; Motter 1998; Posner and DiGirolamo 1998, 2000; Rafal 1996).

In neurocognitive and meditative research, researchers tend to agree on the existence of two main attention centers in the brain. One center, located in the posterior region of the brain, is responsible for bringing attention to stimuli and taking attention away. The second, located more anteriorly, is responsible for regulatory functions of attention (Austin 1998;d'Aquili and Newberg 1999; Posner and DiGirolamo 2000; Posner and Peterson, 1990; Posner and Rothbart 1991). These two systems are highly interconnected and they influence processing throughout the brain, yet they can also work independently.

According to Posner and colleagues (Posner and DiGirolamo 2000; Posner and Peterson 1990; Posner and Rothbart 1991), the Posterior Attention Network includes connections among the pulvinar nucleus of the thalamus, the collicular nuclei of the midbrain, and the posterior parietal lobe. Damage to any one of these structures affects the orienting of attention. Orienting of attention involves engaging attention to a target, disengaging attention from a target, and moving attention. Therefore, the Posterior Network is important for *selection*: bringing attention to a target and switching attention to a new target.

In meditation research, Austin (1998) highlights the importance of connections between the subcortical pulvinar nucleus of the thalamus and the posterior parietal lobe in attention. In particular, the pulvinar nucleus is responsible for engaging attention and the posterior parietal lobe for disengaging attention (p. 370). Additionally, d'Aquili and Newberg suggest that the Orientation Association Area, which is located in the posterior parietal lobe, is responsible for generating a sense of space and allowing orientation to incoming stimuli (1999, p. 112). This Orientation Association Area is closely related, if not identical, to the Posterior Attention Network proposed by Posner and colleagues (see Posner and Peterson 1990).

Multiple lines of evidence suggest that the Anterior Attention Network proposed by Posner and colleagues, comprised of prefrontal cortex (PFC) and anterior cingulate, is responsible for *control* over our attention (see Posner and DiGirolamo 1998, 2000; Posner and Rothbart 1991). Anatomically, the PFC is situated and connected with other brain regions so as to impart top–down influence throughout the brain (see Miller 2000). It is connected with the temporal lobes for executive control of voluntary recall of memories (Tomita et al. 1999), and it is intricately connected to the posterior parietal lobe, involved in the disengaging of attention (see Desimone and Duncan 1995). Humans with damage to PFC lose the ability to control where their attention is directed (e.g., WCST, Stroop test) (see Braver et al. 2001), and these patients become highly distractable. Similarly, "patients who have sustained damage to their right frontal lobe cannot pay attention during a monotonous, repetitive task" (Austin 1998, p. 274, citing research by Willkins, et al. 1987; Woods and Knight 1986).

Single-cell recording studies (Fuster 1989; Goldman-Rakic 1987) found that cells in dorsolateral PFC were active during the delay in delayed response tasks. The dorsolateral PFC has also been implicated in context processing and maintaining task-relevant information in working memory (Braver et al. 2001). Activity of the dorsolateral PFC is mediated by the neurotransmitter dopamine; drugs that block the activity of dopamine (such as haloperidol, an antipsychotic) impair cognitive control, while drugs that enhance dopamine (such as amphetamine) can improve cognitive control (see Braver et al. 2001, p. 749). The dorsolateral PFC is also connected with the area of the brain involved in pleasure, the ventral tegmental area and nucleus accumbens, which rely on dopaminergic input. Therefore, cognitive control and the dopamine reward pathway are related (Miller 2000). In addition to the dorsolateral PFC, the anterior cingulate cortex is also involved in attentional processing and is activated during times of target or error detection (Posner and Rothbart 1991). Anterior cingulate cortex and dorsolateral PFC are also active during dual task situations (Posner and DiGirolamo 1998, 2000). Interestingly, once a task is well-practiced, executive control of attention is no longer required and dorsolateral PFC and anterior cingulate areas are no longer active (Abdullaev and Posner 1997). As reported by Posner and DiGirolamo: "[the anterior cingulate cortex] is especially active during tasks that require some thought and is reduced or disappears as tasks become routine" (1998, p. 411).

In their neurobiological model of meditation, d'Aquili and Newberg (1999) include an Attention Association Area. This system, located in the PFC, is akin to the Anterior Attention Network proposed by Posner and colleagues (see Posner and Peterson, 1990). D'Aquili and Newberg emphasize the connections between PFC and the limbic system, which is important for the modulation of emotion, as well as other connections described earlier.

Posner and Peterson (1990) also proposed a third attentional network—the Vigilance Network—which allows one to sustain attention over a period of time. This sustained attention is achieved by activating the cortex from the locus coeruleus, a nucleus in the midbrain, which is part of the ascending activating systems (Kolb and Whishaw 2003). These cortical projections include target regions of the Anterior (dorsolateral PFC and anterior cingulate cortex) and Posterior (posterior parietal lobe) Attention Networks. For example, a PET scan study has shown that a vigilance task, in which participants maintained attention in order to detect frequent auditory targets, activated the right lateral midfrontal lobe and decreased activation in the anterior cingulate (Cohen et al. 1988). The Vigilance Network is intricately connected with both the Posterior Attention Network (Morrison and Foote 1986) and the Anterior Attention Network (Posner and Rothbart 1986).

Integrating Neurocognition and Phenomenology: An Example

So, how do attention and metacognition work together in every day experience? In our daily lives, a quiet environment with few distractions is highly unusual. Most often, we find ourselves trying to manage information "overload." As Baars (1997) points out:

> In an overload situation (e.g., when working memory is already completely loaded), "metacognition" will be impaired or impossible, and all the activities that require metacognition—self-monitoring, skepticism, deciding what to pay attention to next—may be lost. (1997, p. 102)

We rely on the three networks of attention when put in an overload situation. The Vigilance Network from the locus coeruleus provides excitatory input to the cortex. This network connects both with the Posterior and Anterior Attention Networks to help maintain arousal and focus. The Posterior Network selects the focus of attention. The cingulate cortex in the Anterior Network is activated when a target is detected. The Posterior Network is also responsible for making shifts in attention driven by "bottom–up processes," such as when an "orienting" of attention is guided by particular stimulus features. Or the Anterior Network may direct the Posterior Network to shift attention based on intention or other top–down processes (see Posner and Rothbart 1991).

The Anterior Attention Network is also responsible for our capacity to ignore distracting information, to monitor and also regulate where attention is. All of these attentional processes (arousal, selecting, monitoring) consume attentional resources. As Posner and DiGirolamo (1998, 2000) have demonstrated, as one becomes more familiar and practiced with particular tasks, more of the processing become automatic, there is less need to regulate attention, and, hence, less reliance on the Anterior Attention Network.

Pause for a moment and focus on the words "North Dakota." Think of *nothing but* the words North Dakota for 30 seconds. Close your eyes for this brief exercise, then return to our discussion. This task requires sustained, selective attention; *sustained* because we asked you to hold this thought for a period of time, and *selective* because you were to focus on one thing and ignore all other irrelevant information. This task also requires metacognitive skills: you have to set the "intention" to think about North Dakota; you need to "monitor" whether you are, in fact, thinking about North Dakota; and you must return your attention to North Dakota if you get distracted (regulate).

So, what was your experience with the North Dakota exercise? Were you distracted by unrelated thoughts, feelings, or sensations? Did your mind move to things associated with North Dakota? Did you think of its capital

(Bismarck), its location in the United States relative to your location, or that Bismarck is a type of donut? Did you think of something completely unrelated? Did you even notice that your attention wandered from the words North Dakota? If you are like most of us, you found it difficult to sustain just the one thought without your attention being automatically drawn to some other thought, sensation, emotion, or memory. Perhaps the last time you had a donut you became sick and you found yourself remembering this incident. Now you have moved from a state in North America to a memory of an illness, with no clear path from one point to the other.

The intention may be to direct our attention (e.g., to North Dakota), but attention is easily, even automatically, distracted by associated thoughts, feelings, sensations, or memories, as illustrated in figure 5.2. This example shows how we can move swiftly from one related or unrelated topic to the next without being consciously aware of any one thought, or of the chain of

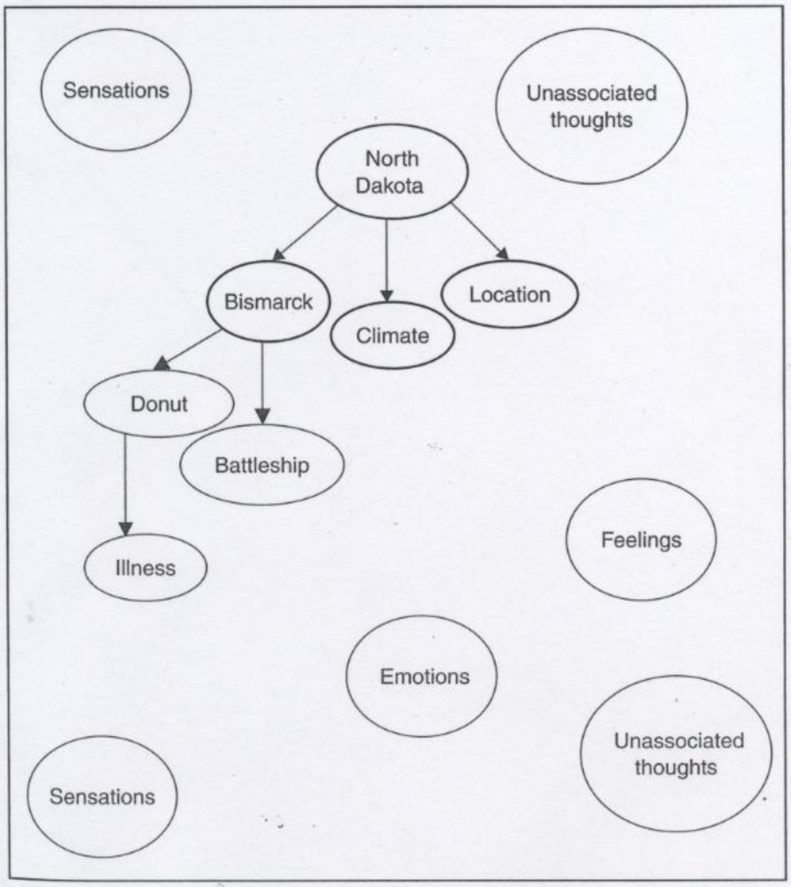

Figure 5.2 Illustration of representative associations automatically activated in the "North Dakota" selective, sustained attention task.

associations (see LaBerge 1995). Ellen Langer (1989,2000) terms this process "mindlessness." Normally, we would not question our ability to sustain our attention on the two words North Dakota, nor would we be particularly interested in the outcome of such a simple thought exercise. Consider, however, that unless your attention remained focused solely on the words North Dakota for those 30 seconds, you were distracted and did not successfully complete this brief task!

Why is attention so easily distracted in the North Dakota exercise? We suggest that it is largely because of how attentional resources are allocated. As mentioned previously, Lavie and colleagues demonstrated that distracting information is more likely to be processed when the target does not utilize all of our capacity or cognitive resources for attention. Since the target thought, North Dakota, does not require much of your attentional capacity, distractors will compete for your attention. With the remaining capacity, you might process and be distracted by an external event, such as the telephone ringing in the next room. Also, persistent distraction arises from the associated thoughts, feelings, memories, and sensations that are automatically activated when, in this case, you hear North Dakota. Attentional focus may be drawn away from North Dakota in order to more fully process these associated thoughts or to follow thoughts associated with the associates. The notion of a *train* of thought is certainly apt here! (Also see the semantic activation model of memory developed by Collins and Loftus 1975.) Alternatively, we may find that we cannot sustain our attention to North Dakota, and our attention simply wanders to an unrelated thought, feeling, sensation, or external event. In our view, all of the attentional and regulatory processes mentioned here consume cognitive resources: selecting in a target (selection); selecting out a distractor (ignoring); maintaining focus on a target (sustaining attention); and checking or intentionally changing where one's attention is directed (regulation). So even if one is successful in avoiding distraction from North Dakota, because so many attentional resources are devoted to monitoring, regulating, maintaining interest, etc., minimal attentional resources remain to concentrate on North Dakota.

Attention and Metacognition in Zazen

> To master the vast process of thought, to erect a temple of intellectual understanding from the top of which we "see" as never before, we must first clear the site.
>
> —Christmas Humphreys, *A Western Approach to Zen*

In zazen, an individual maintains a specific posture for a period of 30–40 minutes usually in a setting where external environmental stimuli and potential distractions are minimized (see, especially, Okumura 1985 for a description of the formal instructions for zazen). In the words of Dogen Zenji:

> In our zazen, it is of primary importance to sit in the correct posture. Then, regulate the breathing and calm down. In Hinayana, there are two elementary ways (of beginner's practice): one is to count the breaths, and the other is to contemplate the impurity of the body. (Cited by Okumura 1985, p. 29)

Numerous accounts of the phenomenology of zazen describe the inherent distractibility of mind, or the "monkey mind" (see, especially, Aitken 1982; Humphreys 1971; Suzuki 1970). Thus, even though a novice meditator may engage in zazen with an *intention* to focus on the breath, he or she soon discovers that the mind is restless and reactive and not easily given to the seemingly simple task of "following the breath."

Our earlier discussion of attention foreshadowed three reasons why distraction should be highly likely during zazen. First, selecting the breath as the focus of attention seems to be a simple, undemanding task. As such, it should not consume much attentional capacity. With considerable capacity available to process irrelevant information, we would expect distraction to occur readily, even when external distractors have been minimized (see Lavie and Cox 1997; Lavie and Fox 2000). Second, distraction during zazen is likely even for those highly motivated to sustain their attention on the breath. As we saw in the research on sustained attention, a large decrement in sustained attention occurs within the first 15 minutes and performance continues to decline thereafter (Parasuraman et al. 1998). Finally, because of the inherent potential for distraction during zazen, the executive system must be actively engaged in order to regulate attention. Thus, in addition to attentional processing (selection and sustaining), zazen also entails the metacognitive processes of *intentionality, self-monitoring*, and *self-regulation* (see, especially, Metcalfe and Shimamura 1994; Nelson 1992; Nelson and Narens 1990). Each of these processes consume resources, leaving minimal resources available for the moment.

With continued practice, the novice begins to notice what distracts her and even to label the type of distraction ("thinking,""emotion,""judgment") without being drawn into the extended associative process typically triggered by the content of a distracting thought, sensation, or feeling. she develops the ability to return her attention to the breath (to her ongoing, moment-by-moment experience) without judgment or commentary (see Cleary 1995; Hanh 1976; Kapleau 1965). Because attending to the breath demands few attentional resources, considerable cognitive resources are available for metacognitive processes. These metacognitive processes include monitoring and regulating, for example, *what* the mind is attending to, such as the breath or the rise and fall of thoughts, feelings, sensations, and *how* the mind is attending/selecting objects of attention, as well as *how* attention is returned to the breath when distractions occur. Although these cognitive and metacognitive processes themselves consume cognitive resources (see, especially, Baars 1997, 1988; Lavie and Fox 2000), sufficient capacity is presumably available with a task as simple as "counting the breath."

Thus, we see that zazen involves the practice of *sustained, selective attention* (to one's moment-by-moment experience) and the practice of sustained, selective attention requires metacognitive skills, especially for novice practitioners.

Before one begins the practice of meditation, one typically exerts little executive control over cognition due to automaticity of cognition (see Bargh and Chartrand 1999; Langer 1989, 2000). Shortcuts and automatic associations gained through a lifetime of experience move us away from experiencing the moment. As Blackstone and Josipovic note, "In Zen practice, we are trying to become beginners, to experience life without the interference of our whole accumulation of opinions and ideas" (1986, p. 12).

In early meditative practice, the novice attempts to develop executive control over attention and cognition (Wallace 1991). These supervisory and regulatory processes consume resources, limiting the attentional capacity available for attending to the moment. With practice, however, one may become more "mindful." In contrast to our usual experience of mental distractibility, when one is mindful, one experiences "an enhanced attention to and awareness of" what is happening in the moment (Brown and Ryan 2003, p. 822; also see Hanh 1976; Langer 1989, 2000). Mindfulness is akin to what LaBerge (1995) described as maintenance attention. Mindfulness (present-centered awareness) makes it possible to observe the mind dispassionately and to discover for oneself fundamental insights into human nature. As Robert Aitken explains: "We are concerned with realizing the nature of being, and zazen has proved empirically to be the practical way to settle down to the place where realization is possible" (1982, p. 14).

The practice of zazen, then, is considered the doorway to an enlightened understanding of our mental and emotional conditioning and how this conditioning gives rise to dissatisfaction ("suffering") and belief in a separate, unchanging self (Cleary 1995; Hanh 1998; Okumura 1985).

Empirical Evidence of the Interplay of Attention and Metacognition in Zazen

> The thought-machine must be brought under control, in order that it may be rightly used to raise consciousness to its limits and beyond. The operative word is "control". Look once more at the ideal, "to let the mind abide nowhere," to use it—as a bird flying free, as a car which is never stuck to the road it uses.
>
> —Humphreys, *A Western Approach to Zen*

In addition to phenomenological reports, cognitive–behavioral studies of attention in novice and practiced meditators offer evidence that the interplay between attention and executive functions differs for novice and practiced meditators.

A study conducted by Valentine and Sweet on the effects of concentrative and receptive meditation on sustained attention tested the following hypotheses:

1. Since both concentrative and receptive meditation involve the training of attention, it was predicted that people practicing either type of meditation would show superior performance on an attentional task when compared with controls.
2. Since increased practice of meditation should train attention further, it was predicted that long-term meditators would show superior performance, again when compared with controls (1999, p. 63).

The first hypothesis was examined by comparing the performance of concentrative and mindfulness meditators with a control group of non-meditators on Wilkins's Counting Test sets 1 and 2. Wilkins's Counting Test is a vigilance task and requires sustained focused attention. In the test, a series of trials made up of binaural auditory tones, randomly varying in length from 2 to 11 bleeps, are delivered at different rates. The task is to count the bleeps and report the number presented at the end of each series. The sets consist of auditory stimuli presented at a relatively slow rate (0.25 Hertz) during an 18-minute session. To test the second hypothesis described above, the performance of long-term and short-term meditators was compared. The 19 meditators were members of a Buddhist center, 8 males and 11 females, with a mean age of 33. Participants were classified as concentrative meditators if they agreed with the statement: "I focus my attention as far as possible to a single point—a mental image, a perceptual object, breath, sound, or thought" (p. 63). Long-term meditators were those who had practiced for 25 months or more and short-term meditators were those who had practiced for 24 months or less. The control group consisted of 24 second-year college students, 14 females and 10 males, with a mean age of 22. They were considered to be comparable on an intellectual level with the meditators.

The results of Valentine and Sweet's study confirmed their hypotheses. First, meditators' performance was better than that of controls on sets 1 and 2 of Wilkins's Counting Test. Mean total estimates were significantly higher for meditators (M score of 197.48) than for controls (M score of 169.87) (p. 65). Also, long-term meditators showed further increments in attention in comparison with shortterm meditators with mean scores on the Wilkins's test of 202.6 vs. 190.77, respectively. The authors concluded that the practice of zazen appears to lead to improvements in sustained selective attention. It must be noted, however, that results from cross-sectional studies (those that compare the characteristics of non-randomly assigned groups) must be interpreted with caution due to the likelihood of important confounds. For example, Valentine and Sweet's samples of long-term meditators were not comparable to the short-term meditators on important variables such as age, distribution of male/females, and selection process. The observed group differences in attentional skills may well be associated with meditative practice, but these differences may be more strongly associated with other variables. As well, *changes* in attentional skills cannot be discovered in a cross-sectional study. Change over time can only be reliably revealed in experimental or quasi-experimental studies that involve repeated measures on the same individuals and where careful attention is paid to insuring that the experimental and comparison group(s) are comparable. These qualifications do not invalidate Valentine and Sweet's conclusions; they simply underscore the need for additional, controlled studies and the importance of replicating important findings. Other research has been conducted that is consistent with Valentine and Sweet's conclusions. For example, several studies found that meditators perform better on standard psychological attention tests (e.g., Davidson et al. 2003; Novak 1990; Rani and Rao 1986).

The above cognitive–behavioral research provides evidence consistent with the hypothesis that the meditative practice of zazen improves one's ability to sustain selective attention (also see Wallace 1991). We are also interested in the neurobiological correlates of zazen and in whether neural changes occur as a person becomes more experienced at Zen meditation. We saw earlier that the attentional capacities of practiced meditators differ from those of non-meditators. Meditation has been shown also to have carryover effects to psychological well-being, behavior, and physiological functions (see Brown and Ryan 2003; Davidson et al. 2003; Epstein 1995; Rosenberg 2004; Shapiro et al. 1998). If meditation affects behavior, and behavior relies on the activity of the brain, then it follows that meditation is associated with lasting changes in brain activity. Although Austin published "Zen and the Brain" in 1988, research into the neurobiological basis of meditation is still in its infancy. Much of the empirical work examining the biology of meditation has focused on EEG recordings (see Blackmore 2004, for a summary of this work). Other than Austin's (1988) intensive case study and preliminary studies reported by d'Aquili and Newberg (1999), little research on attention and zazen has been conducted using newer and more powerful techniques.

Further Speculations on Zen and the Brain

> Buddhism is, above all, a method of inquiry into oneself. That inquiry supposedly reveals the emptiness and impermanence of all phenomena, the illusory nature of self, and the origins and ending of suffering.
>
> —S.Blackmore, *Consciousness*

In our previous discussion, we noted the importance of two independent, yet interrelated, attention networks in attentional functioning. One system, located in the parietal lobes, is responsible for orienting, engaging, and disengaging attention. This attentional system was called the Posterior Network by Posner and Peterson (1990) and the Orientation Association Area by d'Aquili and Newberg (1999). The second system, located in the front of the brain in the frontal lobes, was called the Anterior Attention Network by Posner and Peterson (1990) and the Attention Association Area by d'Aquili and Newberg (1999) and is responsible for executive control of attention.

Recall that Posner and DiGirolamo (1998, 2000) reported that once a task was well-practiced, activity in the dorsolateral PFC and anterior cingulate decreased, indicating a decrease in executive functions. Surely, the dorsolateral PFC and anterior cingulate cortex also make appropriated adjustments as attentional skills are developed with meditative practice. For example, whereas these areas would be involved in regulating and controlling attention in novice practitioners, the need for cognitive control would be reduced, perhaps even eliminated, with long-term practice. Alan Wallace's description of the nine stages of attentional training ("samatha") in Tibetan Buddhist practice is consistent with such a perspective: "With the attainment of the ninth state [of attentional training] called *balanced placement* . . . only an initial impulse of will and effort is needed at the beginning of each meditation session; for after that, uninterrupted, sustained attention occurs effortlessly" (1999, p. 182).

In terms of neural activity, even in advanced stages of attentional training, we would expect activity in the PFC. In fact, an increase in frontal lobe activity in meditators has been reported. Using PET scan techniques, Austin (1998) noted that during rest, the brain activity of an experienced meditator (himself) was different from that of a non-meditator who was also resting. In particular, he noted increased activity in his frontal lobes compared to non-meditators. This increased frontal lobe activity has also been reported during meditation (d'Aquili and Newberg 1999) in meditators compared with non-meditators.

What might this increase in activity mean? Since executive functions are no longer consuming the cognitive resources that were required to regulate and monitor attention, these resources become available to "fully engage the moment"; hence, the corresponding increase in frontal lobe activity such as reported by Austin (1998) and d'Aquili and Newberg (1999). In other words, the long-term practice of zazen does not involve the automatization of executive functions, but rather a change in how these resources are deployed; that is, there is less attentional regulation and more noticing of the varied qualities of present-moment experience.

The Vigilance Network (locus coeruleus input to cortex) also influences the activity of the Anterior Attention Network, as demonstrated by Cohen et al. (1988). In particular, they found that a vigilance task, in which participants maintained attention in order to detect infrequent auditory targets, caused a decrease in activity of the anterior cingulate. Recall that anterior cingulate activity is related to target detection. Posner and Rothbart (1991) speculate the decrease in anterior cingulate activity during sustained attention tasks results in the feeling of being "empty-headed" in that one may suspend other cognitive activity in order to avoid stray thoughts, which may otherwise interfere with target detection. This situation exemplifies what

LaBerge (1995) called "preparatory" attention. Preparatory attention involves maintaining attention with an associated expectation in mind, such as detecting infrequent targets as in the vigilance task mentioned earlier. Attention is sustained because an upcoming event (the target) is of interest.

Maintenance attention, according to LaBerge (1995) involves sustaining attention over a period of time with no goal or expectation in mind. Attention, in this case, is sustained, not with the expectation that something interesting *will* happen, but rather because what is happening *now* is of interest. LaBerge suggests some examples of events that may invoke maintenance attention, such as "observing ocean waves, flames leaping in a fireplace, a bird in flight, a series of pictures in an art museum" (p. 92). LaBerge suggests that attention is maintained under these conditions because of internal cognitive processes and the characteristics of the external stimulus. Does one feel empty-headed during tasks involving maintenance attention, as they might during vigilance tasks requiring preparatory attention? Likely no, because the person is fully aware and engaged with what is happening in the moment. In other words, in a vigilance task, one can likely engage preparatory attention rather "mindlessly." On the other hand, when one's maintenance attention is engaged, attention is fully devoted to present experience and one is mindful. To our Western sensibilities, mindfulness may seem like a small accomplishment. However, in Buddhist practice, mindfulness is central. As Thich Nhat Hanh explains: "Mindfulness is the energy that sheds light on all things and all activities, producing the power of concentration, bringing forth deep insight and awakening. Mindfulness is at the base of all Buddhist practice" (1974, p. 26).

In contrast to Western studies of attention, where there is little or no discussion of the self who is attending, in Zen, the nature of mind and self are themselves explored and questioned: "Who" is doing the attending? What is this self composed of? Where is this self? Is the self really as stable over time as we tend to believe? (See, especially, Aitken 1982; Blackmore 2004; Varela et al. 1991.) The aim of Zen, according to Humphreys, is "to reach the end of thought and then, by the power of the thought-machine itself, to break out of its limitations into Prajna-awareness, a direct vision of 'things as they are' " (1971, p. 132).

Directions for Future Research

In the final chapters of her recent comprehensive text on consciousness, Susan Blackmore discusses the interests shown by many psychologists and neuroscientists in the Buddhist, and especially Zen, methods of investigating the nature of the mind:

> Buddhism is, above all, a method of inquiry into oneself. That inquiry supposedly reveals the emptiness and impermanence of all phenomena, the illusory nature of self, and the origins and ending of suffering . . . Within Buddhism, psychologists have found both methods

and theories that touch on the deepest mysteries in the psychology of consciousness. (2004, p. 402)

Several other contemporary cognitive scientists and neuroscientists have also highlighted the potential of meditative practice, both for one's personal development and as a means to deepen scientific understanding of cognition and consciousness (see, especially, Austin 1998; d'Aquili & Newberg 1999; Hunt 1995; Varela et al. 1991).

For example, consider the number of recent models of consciousness and cognition that discuss executive functions at length (e.g., Austin 1998; Baars 1988, 1997; John 2003; Newman and Baars 1993; Rees et al. 2002; Solms and Turnbull 2002; Umitla 2000). These theories vary in the proposed specific relations among attention, awareness, and consciousness. Couple this fruitful research with the burgeoning interest in the neuroscience of subjective experience and evermore sophisticated brain imaging technologies, and the time is ripe to extend the boundaries and contributions of cognitive neuroscience.

We hope that we have successfully made the case for the value of a neurocognitive consideration of the training of attention in zazen. Such an approach reveals "attention" in zazen as considerably more nuanced than was suggested by the opening Zen story: a variety of attentional skills is intentionally practiced and developed (selective attention, sustained attention, maintenance attention); executive and metacognitive skills are also required in order to monitor and regulate attention; and intentionality (volition) guides and sustains the difficult practice of present-centered awareness. Ideally, this chapter will make a constructive contribution to future investigations of the complex relationships among the component cognitive processes associated with meditation and consciousness, investigations that of necessity will converge phenomenological, cognitive, behavioral, and neural approaches.

Notes

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1. As is often noted by those writing about the practice of zazen, we acknowledge the inevitable difficulty in trying to even peripherally describe the often ineffable experiences that arise during meditative practice. In our own way and in relation to our own depth of experience with zazen, we are attempting to characterize the seemingly simple activity of bringing one's attention to the present moment. Inevitably, one must undertake his or her own direct investigation of the nature of mind.

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