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Chapter 1

Hierarchical Information Processing: Cognitive, Emotional, and Sensorimotor Dimensions

FOR TRAUMATIZED INDIVIDUALS, THE DEBILITATING, repetitive cycle of interaction between mind and body keeps past trauma "alive," disrupting the sense of self and maintaining trauma-related disorders. Many people are left with a fragmented memory of their traumatic experiences, a host of easily reactivated neurobiological responses, and baffling, intense, nonverbal memories—sensorimotor reactions and symptoms that "tell the story" without words, as though the body knows what they do not know cognitively. They are often unaware that these reactions—intrusive body sensations, images, smells, physical pain and constriction, numbing, and the inability to modulate arousal—are, in fact, remnants of past trauma. Frequently uncertain of what happened and how they endured it, traumatized individuals tend to interpret these reactivated sensorimotor responses as data about their identity or selfhood: "I am never safe," "I am a marked woman," "I am worthless and unlovable." These beliefs are reflected in the body and affect posture, breathing, freedom of movement, even heart rate and respiration (Aposhyan, 2004; Caldwell, 1997; Heckler, 1993; Keleman, 1985; Kepner, 1987, 1995; Krueger, 2002; Kurtz, 1990; Kurtz & Prestera, 1976; Lowen, 1975; Reich, 1945/1972; Rosenberg, Rand, & Asay, 1985). And each somatic adaptation to trauma, in turn, influences how traumatized people respond to the environment and make meaning of all subsequent experience.

Rather than helping to resolve these symptoms, attempts to process traumatic events by describing them in words or venting the associated feelings can precipitate "somatic remembering" in the form of physical sensations, numbing, dysregulated arousal, and involuntary movements. These intense bodily responses, in turn, can fuel trauma-related emotions of terror, dread, helplessness, hopelessness, shame, and rage. Attempting to describe traumatic events thus brings the past suddenly into the present, and orientation to current reality may be partially or temporarily lost (Tarrier et al., 1999; Burnstein, Ellis, Teitge, Gross, & Shier, 1986; McDonough-Coyle et al., 2000; Pitman et al., 1991; Scott & Stradling 1997; Devilly & Foa 2001; Tarrier, 2001). "Remembering" the trauma is experienced as "It's happening *again*—I'm still not safe." At those moments of feeling under threat, the "thinking" mind—the frontal cortex—is compromised. Accordingly, subsequent decisions and actions based on the bodily experience of threat tend to be impulsive, dangerous, or otherwise inappropriate to current reality. Yet again trauma-related beliefs—that is, beliefs that exacerbate somatic symptoms—feel confirmed: "It must be true that nothing good can happen to me"; "It must be true that I don't deserve to be safe."

The complexity and variety of symptoms affecting both mind and body are perplexing to therapists and clients alike. Highlighting the role of dissociation in trauma symptoms, Pierre Janet (1889) emphasized that unresolved trauma results in profound deficits in the ability to integrate experiences. Processes that are normally unified, such as emotions, thoughts, identity, memory, and somatosensory elements, are separated (Spiegel & Cardena, 1991). This integrative failure leads to an undue "compartmentalization of experience: Elements of a trauma are not integrated into a unitary whole or an integrated sense of self" (van der Kolk, Van der Hart, & Marmar, 1996, p. 306). One form of compartmentalization is apparent in the propensity of traumatized individuals to alternate between (1) emotional and bodily numbing and avoidance of cues reminiscent of the trauma and (2) intrusive reliving of the trauma via flashbacks, dreams, thoughts, and somatic symptoms (Chu, 1998; Meyers, 1940; Spiegel, 1990, 1997; van der Hart et al., 2004; van der Kolk & Van der Hart, 1989). In the words of James Chu, "This biphasic pattern is the result of dissociation: traumatic events are distanced and dissociated from usual conscious awareness in the numbing phase, only to return in the intrusive phase" (1998, p. 33).

Markedly different symptoms occur in each dissociative phase. In the intrusive phase, the person is plagued by unintegrated fragments of traumatic memories that return unbidden. In the numbing phase, these fragments are kept at bay, but the individual feels numb and detached, living "on the surface of consciousness" (Appelfeld, 1994, p. 18). The dissociative symptoms in each phase are further complicated by being both psychological, or psychoform, *and* sensorimotor, or somatoform (Nijenhuis & Van der Hart, 1999; Van der Hart, Van Dijke, Van Son, & Steele, 2000). Psychoform symptoms involve dissociation of mental functions and manifest as overwhelming affects, concentration difficulties, amnesia and other memory problems, and altered systems of belief. Somatoform dissociative symptoms involve body sensation, movement, and the senses, and include sensory distortions, dysregulated physiological arousal, lack of body sensation, pain, movement disorders, and reexperiencing the trauma in somatosensory fragments. Van der Hart and colleagues aptly noted that the psychoform and somatoform symptoms should be viewed as two sides of the same coin, because "they are both expressions of underlying dissociative processes that transpire within the inseparable union of psyche and soma" (2000, p. 35). The complicated mix of somatoform and psychoform symptoms begs for a treatment approach that directly addresses the effects of trauma on both the body and the mind.

The Triune Brain

The capacity of human beings for self-awareness, interpretation, abstract thought, and feeling exists within a developmental and hierarchical relationship to the instinctual and nonconscious responses of the body. These hierarchically organized evolutionary responses range from instinctual arousal and physical defenses to feelings and emotional experience to thoughts, self reflection, beliefs, and meaning making.

Wilber's (1996) notion of hierarchical information processing described the evolutionary and functional hierarchy among three levels of organizing experience: cognitive, emotional, and sensorimotor levels. In neuropsychology a parallel understanding of this hierarchy was articulated by MacLean, who portrayed the concept of the triune brain as a "brain with a brain within a brain" (1985, p. 8). The reptilian brain, first to develop from an evolutionary perspective, governs arousal, homeostasis of the organism, and reproductive drives, and loosely relates to the sensorimotor level of information processing, including sensation and programmed movement impulses. Correlating with emotional processing, the "paleomammalian brain" or "limbic brain," found in all mammals, surrounds the reptilian brain and mediates emotion, memory, some social behavior, and learning (Cozolino, 2002). Last to develop phylogenetically is the neocortex, which enables cognitive information processing, such as self-awareness and conscious thought, and includes large portions of the corpus callosum, which bridges the right and left hemispheres of the brain (MacLean, 1985) and helps consolidate information (Siegel, 1999). Thus the three levels of information processing—cognitive, emotional, and sensorimotor—can be thought of as roughly correlating with the three levels of brain architecture.

Different kinds of knowledge originate from each of these brains. The reptilian brain produces "Innate behavioral knowledge: Basic instinctual action tendencies and habits related to primitive survival issues" (Panksepp, 1998, p. 43). The limbic system provides "Affective knowledge: Subjective feelings and emotional responses to world events" (Panksepp, 1998, p. 43). The neocortex generates "Declarative knowledge . . . propositional information about world" (Panksepp, 1998, p. 43). Panksepp further clarified the behavioral and functional interface of these three "brains":

> The inner most reptilian core of the brain elaborates basic instinctual action plans for primitive emotive processes such as exploration, feeding, aggressive dominance displays, and sexuality. The old-mammalian brain, or the limbic system, adds behavioral and psychological resolution to all of the emotions and specifically mediates the social emotions such as separation distress/social bonding, playfulness, and maternal nurturance. The highly expanded neomammalian cortex generates higher cognitive functions, reasoning, and logical thought. (p. 43)

Each of the three levels of the brain thus has its own "understanding" of the environment and responds accordingly. A particular level may become dominant and override the others, depending on the internal and environmental conditions. At the same time, these three levels are mutually dependent and intertwined (Damasio, 1999; LeDoux, 1996; Schore, 1994), functioning as a cohesive whole, with the degree of integration of each level of processing affecting the efficacy of other levels. Fisher, Murray, and Bundy (1991) noted:

> The brain functions as an integrated whole but is comprised of systems that are hierarchically organized. The "higher level" integrative functions evolved from and are dependent on the integrity of "lower-level" structures and on sensorimotor experience. Higher (cortical) centers of the brain are viewed as those that are responsible for abstraction, perception, reasoning, language, and learning. Sensory integration and intersensory association, in contrast, occur mainly within lower (subcortical) centers. Lower parts of the brain are conceptualized as developing and maturing before higher-level structures; development and optimal functioning of higher-level structures are thought to be dependent, in part, on the development and optimal functioning of lower-level structures. (p. 16)

In many ways sensorimotor processing is foundational to other types of processing and includes the features of a simpler, more primitive form of

information processing than do its more evolved counterparts. More directly associated with overall body processing, sensorimotor processing includes physical changes in response to sensory input; the fixed action patterns seen in defenses; changes in breathing and muscular tone; and autonomic nervous system activation. With its seat in the lower, older brain structures, sensorimotor processing relies on a relatively higher number of fixed sequences of steps in the way it works. Some of these fixed sequences are well known, such as the startle reflex and the fight/flight response. The simplest sequences are involuntary reflexes (e.g., the knee-jerk reaction), which are the most rigidly fixed and determined. More complex are the motor patterns that we learn at young ages, such as walking and running, which then become automatic. In the more highly evolved cognitive and emotional realms, we find fewer and fewer fixed sequences of steps and more complexity and variability of response. Panksepp (1998) likened this variance in complexity to the operating systems of a computer:

> Higher functions are typically more open, while lower ones are more reflexive, stereotyped, and closed. For instance, the basic vital functions of the brain—those that regulate organic bodily functions such as respiration—are organized at very low levels. Higher levels provide increasingly flexible control over these lower functions. . . . To use [a] computer analogy . . . the lower functions resemble read-only memory (ROM) "operating systems," which are essential for computers to do anything coherent, while the higher functions resemble random-access memory (RAM) space where increasing complex computations can be done. As more RAM space becomes available, the same operating systems can accomplish more and more. The relative abundance of RAM-like space in humans helps explain the complexity and sophistication of human abilities. (p. 77)

Flexibility and abstraction of response increase at the higher cognitive level of processing; greater fixity and concreteness of response increase at the sensorimotor level. Emotional processing falls in the middle, being neither as flexible as cognitive processing nor as fixed as sensorimotor processing.

The three levels of the brain may not always work well together (MacLean, 1985). In the aftermath of trauma, the integration of information processing on cognitive, emotional, and sensorimotor levels is often compromised. Dysregulated arousal may drive a traumatized person's emotional and cognitive processing, causing emotions to escalate, thoughts to spin, and misinterpretation of present environmental cues as those of a past trauma (van der Kolk, 1996a). For example, a client whose heart rate escalates at the sight of a tall,

overweight, middle-aged man (who is similar in physical appearance to her abusive uncle) and who experiences a somatic sense of wanting to run, is likely to interpret these sensorimotor reactions as meaning that she is not safe. She might then find herself having the thought, "This man is dangerous." This thought, in turn, is likely to increase her heart rate and the tension in her legs and feet, provoking more thoughts, such as "I have to get out of here" and fueling trauma-related emotions of fear and dread. These emotions and sensorimotor reactions further sabotage her ability to appraise current reality accurately.

Although recent authors (Cozolino, 2002; LeDoux, 2002) have challenged the notion of a "limbic system" and emphasized that the neural networks responsible for social, emotional, attachment, and traumatic experiences are found throughout the brain, the concept of the triune brain nevertheless "serves a valuable function of providing a connective metaphor among the artifacts of evolution, the contemporary nervous system, and some of the inherent difficulties related to the organization and disorganization of human consciousness" (Cozolino, 2002, p. 9). We draw on this metaphor to help illustrate how experience is organized on the three levels of information processing and how the synergistic relationship among these levels is chronically impaired by unresolved trauma.

Levels of Information Processing and the Body

Cognitive and emotional processing strongly affect the body, and sensorimotor processing strongly affects cognitions and emotions. In clinical practice, we find it useful to both examine each level of information processing separately and consider the interweaving of cognitions, emotions, and sensorimotor responses. It is especially important for the therapist to observe how the body affects and is influenced by the processing of information on each of these levels of experience. Specific somatic techniques can then be selected and integrated with cognitive and emotional interventions so that adaptive information processing is increased on all three levels.

Cognitive Processing

The term *cognitive processing* refers to the capacity for conceptualizing, reasoning, meaning making, problem solving, and decision making. It encompasses the ability to observe and abstract from experience, weigh a range of possibilities for action, plan for the accomplishment of goals, and evaluate the outcome of actions. Our actions as adults often reflect the hierarchical relationship of volitional cognitive processing over sensorimotor and emotional responses. We can decide (cognitive function) to ignore the sensation of hunger and not act on it, even while the physiological processes associated

with hunger, such as the secretion of saliva and contraction of stomach muscles, continue. In cognitive theory this dominance of cognitive functioning is called "top-down processing" (LeDoux, 1996, p. 272), indicating that the upper level of processing (cognitive) can and often does override, steer, or interrupt the lower levels by elaborating upon or interfering with emotional and sensorimotor processing.

Much adult activity is based upon top-down processing. Schore (1994, p. 139) noted that, in adults, "higher cortical areas" act as a "control center," and that the orbital cortex dominates subcortical activity. We might think about what to accomplish for the day, outline plans, and then structure time to meet particular goals. While executing these plans, emotions and sensations (e.g., frustration, fatigue, physical discomfort) may be overridden. It is as though we hover just above our somatic and emotional experience, knowing it's there, but not allowing it to be the primary determinant of our actions. For the traumatized individual, however, the intensity of trauma-related emotions and sensorimotor reactions hinders the ability of top-down processing to dominate subcortical activity.

Additional difficulty with cognitive processing occurs because traumatized people typically form inflexible, maladaptive interpretations of the trauma or other life experience. Such interpretations take the form of inadvertent, generalized thoughts that are negatively biased and erroneous, such as "I am bad," "It was my fault," "All men are dangerous," and so on. Each thought is an action (Maturana & Varela, 1987)—that is, a mental action (Janet, 1926; Van der Hart, Nijenhuis, & Steele, 2006)—that generates not only more negative cognitions but also corresponding emotions and sensorimotor reactions. These thoughts play a part in the way traumatized people continue to organize their experience, which is shaped by pervasive patterns of cognitive distortions; these distortions result in persistent experiences of low self-esteem and defeat, as well as a chronic perception of a lack of safety.

Cognitive processing is inextricably linked with our bodies. Bodily feelings, or "somatic markers," influence cognitive decision making, logic, speed, and context of thought (Damasio, 1994, 1999, p. 41). The background body sensations that arise during cognitive processing form a biasing substratum that influences the functioning of the individual in all decision-making processes and self-experiences. The "very structure of reason itself comes from the details of our embodiment. The same neural and cognitive mechanisms that allow us to perceive and move around also create our conceptual systems and modes of reason" (Internet Encyclopedia of Philosophy, 2005). The circuits of the brain that are used for mental action are the same ones that are used for physical action (Ratey, 2002). The movement of the body as a child matures is essential for the optimal development of memory, language, and learning. Ratey (2002) speculated that motor neurons may even drive our sense of self-awareness. Thus, how we think and what

we think are literally shaped by the body, and vice versa. According to Lakoff and Johnson (1999):

> The embodiment of reason via the sensorimotor system . . . is a crucial part of the explanation of why it is possible for our concepts to fit so well with the way we function in the world. They fit so well because they have evolved from our sensorimotor systems, which have in turn evolved to allow us to function well in our physical environment. . . . Our concepts cannot be a direct reflection of external, objective, mind-free reality because our sensorimotor system plays a crucial role in shaping them. (p. 4344)

All early relational dynamics with primary caregivers, traumatic or nontraumatic, serve as blueprints for the child's developing cognition and belief systems, and these belief systems influence the posture, structure, and movement of the body, and vice versa. If a child grows up in a family that values high achievement and encourages the child to "try harder" at everything she undertakes, her posture, gesture, and movement will be shaped by this influence. If this value is held at the expense of other values, such as "You are loved for yourself, not for what you do," the child's musculature will probably be toned and tense; her body will be mobilized to "try harder." In contrast, a child who grows up in an environment where trying hard is either discouraged or seen as maladaptive and where everything he achieves is undervalued, might have a sunken chest, limp arms, and shallow breath; his body will reflect a childhood experience of not feeling assertive and confident, of "giving up." It may be difficult for this child to mobilize consistent energy or sufficient self-confidence to complete a difficult task. Chronic postural and movement tendencies serve to sustain certain beliefs and cognitive distortions, and the physical patterns, in turn, contribute to these same beliefs.

If the body shapes reason and beliefs—and vice versa—then the capacity for insight and self-reflection—our ability to "know our own minds"—will be correspondingly limited by the body's influence (Lakoff & Johnson, 1999). How, then, can we begin to know our own minds? If the *patterns* of the body's movements and posture influence reason, cognitive self-reflection might not be the only or even the best way of bringing the workings of the mind to consciousness. Reflecting on, exploring, and changing the posture and movement of the body may be as valuable. For example, Terry came to therapy with a body "filled with fear": His shoulders were hiked up, his head was retracted, his chest was tight with held breath, his eyes darted around, and he had an exaggerated startle reflex. His chronic experience of his body did not support the "reasonable" belief that his past trauma was

over and he was not currently in danger. Terry reported that he *knew* he was safe, but he *felt* as if he were unsafe. In therapy, the sensations and movements of his body were addressed in order to reveal their impact on his beliefs as well as to change both his body and beliefs. In the course of therapy, Terry became aware of this mind–body interface; he worked both cognitively and physically to change his embodied belief by relaxing his shoulders, deepening his breathing, and feeling his legs as firmly grounded and supporting his upper body. During this exploration, memories of his trauma emerged and were dealt with and resolved. After several sessions, Terry described a shift in his body and his beliefs: "Now my body feels like it supports me! I feel safer when my shoulders are more relaxed and my breathing is not so shallow and tense."

Emotional Processing

Emotions add motivational coloring to cognitive processing and act as signals that direct us to notice and attend to particular cues. Emotions help us take adaptive action by calling attention to significant environmental events and stimuli (Krystal, 1978; van der Kolk, McFarlane et al., 1996). The "emotional brain directs us toward experiences we seek and the cognitive brain tries to help us get there as intelligently as possible" (Servan-Schreiber, 2003, p. 26). According to Llinas, "As with muscle tone that serves as the basic platform for the execution of our movements, emotions represent the premotor platform as either drives or deterrents for most of our actions" (2001, p. 155).

Traumatized people characteristically lose the capacity to draw upon emotions as guides for action. They might suffer from alexithymia, a disturbance in the ability to recognize and find words for emotions (Sifneos, 1973, 1996; Taylor, Bagby, & Parker, 1997). They may be detached from their emotions, presenting with flat affect and complaining of a lack of interest and motivation in life and an inability to take action. Or their emotions may be experienced as urgent and immediate calls to action; the capacity to reflect on an emotion and allow it to be part of the data that guides action is lost and its expression becomes explosive and uncontrolled. Through nonverbal remembering triggered by reminders of the event, traumatized individuals relive the emotional tenor of previous traumatic experiences, finding themselves at the mercy of intense trauma-related emotions. These emotions can lead to impulsive, ineffective, conflicting, and irrational actions, such as lashing out physically or verbally, or feeling helpless, frozen, and numb. Emotional arousal in an individual with unresolved trauma thus often provokes action that is not an adaptive response to the present (nontraumatic) environment, but is more likely a version of an adaptive response to the original trauma.

The term *emotional processing* refers to the capacity to experience, describe, express, and integrate affective states (Brewin, Dalgleish, & Joseph, 1996). Emotions usually follow a phasic pattern with a beginning, middle, and an end (Frijda, 1986). However, for many traumatized individuals, the end never arrives. Emotional responses to very strong stimuli, such as trauma, do not appear to extinguish (Frijda, 1986)—a phenomenon that has been demonstrated in animal research by LeDoux, who noted that emotional memory may be forever (LeDoux, 1996). Traumatized individuals are often fixated on trauma-related emotions of grief, fear, terror, or anger. There might be a variety of reasons for this fixation: denial or lack of awareness of the connection between current emotions and past trauma; attempts to avoid more painful emotions; the inability to "think clearly" (Leitenberg, Greenwald, & Cado, 1992); or the inability to distinguish emotions from bodily sensations (Ogden & Minton, 2000). Moreover, the emotions may relate to a variety of past events rather than only one (Frijda, 1986). All these elements contribute to a circular, apparently never-ending reexperiencing of trauma-related emotions.

Like Damasio, Frijda emphasized that emotions are inseparable from the body: "Emotions are . . . matters of the body: of the heart, the stomach, and intestines, of bodily activity and impulse. They are of the flesh and sear the flesh. Also, they are of the brain and the veins" (1986, p. 5). Whether we are aware of these internal sensations or not, they both contribute to, and are the result of, emotions. Butterflies in the stomach tell us we are excited, a heavy feeling in the chest speaks of grief, tension in the jaw informs us we are angry, an all-over tingling feeling indicates fear.

Damasio stated that emotions have two features: first, the internal sensation, which is "inwardly directed and private," and second, visible feature, which is "outwardly directed and public" (1999, p. 40). Internal emotional states are thus experienced as subjective bodily sensations and are reflected in our outward presentation, giving signals to others around us about how we feel. Anger might be visible in the purse of the mouth, clenched fists, narrowed eyes, and general bodily tension. Fear may be communicated in hunched shoulders, held breath, and a pleading look in the eyes or in a bracing or moving away from the frightening stimulus. These bodily stances might be an immediate response to a current situation or a chronic, pervasive emotional state.

In therapy we can utilize the outwardly directed physical manifestations to clarify, work with, and resolve trauma-related emotions. One client who presented with visible tension across her shoulders was directed to notice this tension and explore it for meaning. She reported that it felt like the tension was holding back anger—an insight gleaned from awareness of her body rather than from cognition. This insight led to the realization of an

erroneous belief that she had no right to be angry at her abusive father. Working with the anger through the tension itself (slowly executing the movement the tension "wanted" to make, processing the associated memories, beliefs, and emotions, and learning to relax the tension) assisted this client on her road to fuller self-expression and resolution of the emotions related to her past traumatic events.

In the previous example, working with the client's emotion simultaneously with its cognitive component was effective. However, despite the inextricable involvement of emotions with the body and cognitions, when trauma-related emotions such as terror are coupled with body sensation, such as trembling, the client is encouraged to distinguish body sensations and movements from emotions. In these instances, we help clients differentiate emotional processing from sensorimotor processing. In our vernacular, *emotional processing* pertains to experiencing, articulating, and integrating emotions, whereas *sensorimotor processing* refers to experiencing, articulating, and integrating physical/sensory perception, body sensation, physiological arousal, and motor functioning. This differentiation between these two levels of processing is important in trauma therapy because clients often fail to discriminate between body sensations of arousal or movement and emotional feeling, which can lead to the escalation of both. This lack of discrimination is partly due to the fact that sensation and emotion occur simultaneously and suddenly, and partly because affect dysregulation and degrees of functional alexithymia are characteristic of posttrauma symptoms. Clients often find themselves struggling with the effects of overwhelming emotions, with little awareness of how the body participates in creating and sustaining these emotions.

Conflating trauma-related emotions and the body sensations of physiological arousal can thus complicate the client's capacity to process and resolve the emotions related to traumatic events. If body sensations (e.g., trembling, rapid heart rate) are interpreted as an emotion (e.g., panic), each level of experience—sensorimotor and emotional—inflates and compounds the other. Both the rapid heart rate and the panic are exacerbated when experienced simultaneously. If cognition in the form of a belief is then added, such as "I am not safe," physical sensation and emotion will further intensify. In such a situation, arousal can escalate beyond the person's tolerance, and integrative capacity will be compromised. By working with the client to differentiate the sensation of physiological arousal from emotional arousal, the amount and kind of information are reduced and more ably processed by the client. Physiological arousal can be addressed, and often diminished, by uncoupling trauma-related emotion from body sensation through attending exclusively to the physical sensations of the arousal (without attributing meaning or emotion to them). Then, after the physiological

arousal returns to a tolerable level, the client can look at the emotional contents of the traumatic experience and integrate both.

For example, a Vietnam veteran, Martin, came to therapy to "get rid of" his nightmares and feelings of being chronically emotionally overwhelmed. In the course of sensorimotor psychotherapy, Martin learned to sense his physiological arousal as he experienced it in his body. He learned to pay active attention to his rapid heart rate and the shaking and trembling that he first experienced following the original combat and later reexperienced all too frequently in his daily life. Over several therapy sessions, he learned to describe his inner body sensations, noting the tingling in his arms that occurred prior to the shaking, the slight acceleration in heart rate, and the increase of tension in his legs. As his capacity to observe and describe his subjective bodily sensations developed, he gradually learned to accept these sensations without trying to inhibit them. The therapist instructed him to simply track these sensations as they progressed or "sequenced" through the body. When a client becomes mindfully aware of such internal sensations, the sensations themselves often spontaneously transform into ones that are more tolerable (Levine, 1997). Martin learned to mindfully follow the sequence of sensations as they progressed through his body, until the sensations themselves settled down. He noticed that his shaking gradually dissipated, his heart rate eventually returned to baseline, and the tension in his legs released on its own. After he learned to quiet his arousal in this way, the therapy progressed to address the emotional responses related to the trauma.

Sensorimotor Processing

In contrast to the top-down processing used in the organization of normal adult day-to-day life, the activities of very young children (and many individuals with trauma-related disorders) are dominated by sensorimotor (Piaget, 1962) and emotional systems (Schore, 1994)—in other words, by bottom-up processes. Tactile and kinesthetic sensations guide early attachment behavior as well as help regulate the infant's behavior and physiology (Schore, 2003a). Infants and very young children explore the world through these systems, building the neural networks that are the foundation for later cognitive development (Hannaford, 1995; Piaget, 1962). Hard-wired to be governed by somatic and emotional states, infants and toddlers respond automatically to sensorimotor and affective cues and are unregulated by cognition or cortical control (Schore, 1994). The infant is a "subcortical creature . . . [who] lacks the means for modulation of behavior which is made possible by the development of cortical control" (Diamond, Balvin, & Diamond, 1963, p. 305). Similarly, traumatized people frequently experience themselves as being at the mercy of their sensations, physical and sensory reactions, as well as emotions, having lost the capacity to effectively regulate these functions. In the clinical practice of sensorimotor psychotherapy, we identify three general components of sensorimotor processing: inner-body sensation, five-sense perception, and movement.

INNER-BODY SENSATION

The term *inner-body sensation* refers to the myriad of physical feelings that are continually created by movement of all sorts within the body. When a change occurs in the body, such as a hormonal shift or a muscular spasm, this change may be felt as an inner-body sensation. The contraction of the intestines, circulation of fluids, biochemical changes, the movements of breathing, or the movements of muscles, ligaments, or bones all cause inner-body sensations. The capacity to have some awareness of sensation was referred to as the "sixth sense," first described by Charles Bell in the early 1800s and later by William James in 1889. Today, the sixth sense is understood as resulting from *interoceptors*, the sensory nerve receptors that receive and transmit sensations from stimuli originating from the interior of the body.

There are many different kinds of interoceptors. The kinesthetic sense of the movement of the body as a whole relies on *proprioceptors*, the sensory nerves that terminate in joints, muscles, and tendons. Proprioceptors provide a sense of the body's position in space without having to rely on the visual sense to know where and what position the body is in (Tortora & Anagnostakos, 1990). They relay the position of body parts, the degree of force used in movement, the velocity and timing of movement, and the speed and degree to which a muscle is being stretched (Fisher et al., 1991). The *vestibular system*, a subset of the proprioception that is located in the mechanisms of the inner ear, informs us about the relationship of the body to gravity and controls our sense of balance. This system maintains our equilibrium, primarily of the head, when we are standing still and in response to sudden movements or changes in speed of movements.

The visceral sense, called *enteroception*, tells us about the movements occurring within our internal organs, such as racing of the heart, butterflies in the stomach, nausea, hunger, or that "gut feeling." We have a variety of *nociceptors*, most numerous in the skin and less numerous in tendons, joints, and organs, which relay various kinds of physical pain. *Thermoceptors* respond to temperature. Whereas we are generally unaware of information coming from interoceptors, we can usually turn our attention toward this information at will and detect body sensation: for example, most people can become aware of their heartbeat or the sensation in the viscera after a few minutes of attention.

Through interoceptors, a variety of inner-body sensation is constantly being generated, contributing to internal states of well-being or distress.

However, sensation is usually experienced globally rather than specifically (Janet, 1907). Damasio wrote: "The background body sense is continuous, although one may hardly notice it, since it represents not a specific part of any thing in the body but rather an overall state of most everything in it" (1994, p. 152) As the ongoing background, body sensation is significant in our sense of self: "Consciousness of the 'self' most likely depends to a substantial extent on awareness (however vague, ill-defined, and folded into a larger consciousness) of the body per se, including its visceral organs and functions" (Cameron, 2001).

Although most sensations, unless quite pronounced, do not reach awareness, those that do are influenced by both emotions and cognition. Cioffi (1991, as cited in Bakal 1999) argued that our experience of specific body sensations is strongly determined by meaning and interpretation even when irrelevant to the actual physiological sensations themselves. Bakal (1999) and Cioffi (1991) gave the example of the sensation of cold hands, which could be interpreted as a problem with circulation, or as a normal response to cool air, or as a response to fear. Each interpretation evokes a particular emotional response, which, in turn, contributes to the development of the actual sensation. For example, an interpretation of lack of circulation could promote anxiety, with thoughts of potential medical problems. Anxious reactions may evoke additional body sensations and even colder hands. Thus the experience of sensation—how it develops and whether it increases or decreases—is organized in part by how it is interpreted and the accompanying emotional response.

People with trauma-related disorders suffer from both "feeling too much" and "feeling too little" (van der Kolk, 1994). They often experience inner-body sensations as overwhelming and distressing. The "rush" of adrenaline or the sensations of a rapid heartbeat or of bodily tension are felt acutely and become more disconcerting when interpreted as indicating current danger (Thakkar & McCanne, 2000). These sensations may be even stronger for traumatized people, because interoceptive sensitivity is increased under stress Cameron (2001). Conversely, traumatized individuals commonly suffer from an inability to be aware of body sensation, or an inability to put words to sensation, known as *alexisomia* (Bakal, 1999; Ikemi & Ikemi, 1986). The absence of body sensation and the accompanying interpretation (e.g., "There is something wrong"; "I can't feel my body"; "I feel dead") can be just as distressing as experiencing too much sensation.

The intervention of facilitating awareness of bodily sensation has a long history in the treatment of trauma, and many practitioners believe that helping clients gradually, safely, and comfortably experience their sensations may contribute to resolving symptoms (Aposhyan, 2004; Bakal, 1999; Eckberg, 2000; Janet, 1925; Levine, 1997; Ogden & Minton, 2000; Rothschild, 2000; Sollier, 1897). The capacity to sense and describe sensation and to uncouple it from trauma-related emotions and cognitions enhances the possibility of clients' reintegrating the somatic experience of their trauma in order to establish new meanings and understandings of their past and themselves, as illustrated in the previous example of Martin.

FIVE-SENSE PERCEPTION

Sometimes called *exteroception*, the sensory nerves of our five senses receive and transmit information from stimuli in the external environment. The process of taking in information through the five senses can be thought of as having two components: the physical act of sensing and the individual's perception of the sensory input (Cohen, 1993). Sensory perceptions may dominate traumatized individuals' capacity to think rationally. Dealing with the peritraumatic sensory distortions and the posttraumatic intrusive sensory memory fragments is a necessary component of treatment.

Sensory input from all five senses enters the brain as electrical impulses that are not initially differentiated by the brain (Carter, 1998). What commands our attention from the massive amount of sensory stimulation received each moment is an extremely complex question. Ayres (1989) described the integration of sensory information as

> the neurological process that organizes sensation from one's own body [which occurs from sensory input] and from the environment and makes it possible to use the body effectively within the environment. The spatial and temporal aspects of inputs from different sensory modalities are interpreted, associated, and unified. Sensory integration is information processing. . . . The brain must select, enhance, inhibit, compare, and associate the sensory information in a flexible, constantly changing pattern. (p. 11)

Through this enormously intricate process, we select and filter information, determining what to pay attention to and what to disregard. All learning depends upon our ability to (1) receive sensory information from the environment and the interior of our bodies, (2) synthesize this information, and (3) to organize subsequent behavior. Because this process is influenced by our individual associations with what we sense, it overlaps with the other levels of processing. Llinas described perception as "the functional comparison of internally generated sensorimotor images with real-time sensory information from an organism's immediate environment" (2001, p. 3). Once this subcortical, unconscious comparison has taken place, movement is planned and executed.

Because it is based on the comparison of sensory input with internal frames of reference, our perception—and thus our behavior—is self-referential (Damasio, 1994). Our beliefs and emotional reactions to previous similar sensory stimuli condition our relationship with current stimuli. Without the expectations that influence perceptual priming, each sensory experience would be novel, and we would be quickly overwhelmed. Instead, we fit sensory input into learned categories. Ratey pointed out that "we are constantly priming our perceptions, matching the world to what we expect to sense and thus making it what we perceive it to be" (2002, p. 55). This priming function becomes maladaptive for traumatized individuals, who repeatedly notice and take in sensory cues that are reminiscent of past trauma, often failing to notice concomitant sensory cues indicating that current reality is not dangerous. These real-time trauma-related cues from both the environment and the body are compared to internal sensorimotor images, beliefs, and emotions, ultimately fueling behavior that would be appropriate for threatening situations but not for current nonthreatening situations (Brewin et al., 1996).

MOVEMENT

Movement is included in the sensorimotor level of information processing because of its obvious somatic component, although the frontal lobes of the cortex, rather than the subcortical areas of the brain, are home to the motor cortex and premotor cortex and are responsible for many forms of movement. The same areas of the brain that generate reason and help us solve problems are also involved in movement. Thus movement has shaped, and continues to shape, our minds (Janet, 1925), and vice versa, as articulated by Llinas: "The mind . . . is the product of evolutionary processes that have occurred in the brain *as actively moving creatures* developed from the primitive to the highly evolved" (2001, p. ix, italics added). Movement is essential for the development of all brain functions: Only organisms that move from one location to another require a brain; organisms that are stationary do not (Ratey, 2002).

Movement ranges from voluntary to involuntary, conscious to unconscious, and occurs in many different forms. It includes the rise and fall of respiration, internal movements of organs, pulsation of blood, and pumping of hormones, as well as the small, sometimes imperceptible, vibratory movements such as trembling or twitching. Motor skills range from gross motor movement involving large muscle groups, such as crawling, walking, and running, to fine motor movements of smaller, more refined actions, such as picking up objects with our hands or wiggling our toes. Movement also includes nonverbal interpersonal communications, such as facial expressions, changes in posture or the tilt of the head, or gestures of the hands and arms.

Most overt movement results from sensory perception and in turn helps to shape sensory perception. Movement or motor memory is "achieved from a sophisticated feedback system that detects errors made as the movement is learned. The feedback system uses these errors as a basis from which to generate a new, more accurate sequence of commands, eventually leading to a successful performance. We modify and learn through movement every second of our waking day whether we are active or inactive" (Ratey, 2002, p. 205). Movement memory is apparent in tasks such as tying shoelaces or learning to play a musical instrument. The subtler movement adjustments to environmental and interpersonal cues are less obvious but crucial in determining action tendencies. For instance, if a child is repeatedly met with parental disapproval when he enthusiastically gesticulates and puffs up his chest while describing his success at a game, his expanded chest will deflate and his movements become more restricted. If the criticism is repeated, this constrained movement may become an automatic tendency in interpersonal interactions, in turn affecting perception.

Todd (1959) taught that function precedes structure: The same movement made over and over again ultimately molds the body. For example, when the muscular contractions that prime defensive movements are repeated many times, these contractions turn into physical patterns that affect the body's structure, which in turn, further affects function. Over a long period of time, this chronic tension interferes with the body's natural alignment and movement, creates physical problems (most notably, back, neck, and shoulder pain), and even sustains corresponding emotions and cognitions. Kurtz and Prestera noted: "Such physical patterns become fixed by time, affecting growth and body structure, and characterizing not just the moment, but the person. Rather than simply a present disappointment, the crushed posture of hopelessness could be pointing to a lifetime of endless frustration, and bitter failure" (1976, p. 1).

Repetitive movements and postures thus contribute to the maintenance of cognitive and emotional tendencies by creating a position from which only select emotions and physical actions are possible (Barlow, 1973). We often notice the posture of the startle response in traumatized clients: shoulders up, breath held, head pulled down and forward into the shoulder girdle, similar to a "deer in the headlights." The action of the startle response disturbs the aligned balance between head and shoulders and is usually temporary, but if this normal response to a sudden novel stimulus becomes chronic, the physical organization itself may predispose the individual to experience emotions of fear and distrust and thoughts of impending danger on a chronic basis.

Physical action precedes cognitive and even emotional reactions in acute traumatic situations. Hobson (1994) stated that movement

> takes precedence in times of emergency, when it is advantageous to short-circuit the cortex and activate a motor-pattern generated directly from the brain stem. If we suddenly see a car careening toward us, we instantly turn our car away; we react automatically, and only later (even if it is only a split second later) do we realize there is danger and feel afraid. (p. 139)

When danger is imminent, a person responds with sequences of motor actions that are involuntary and largely predictable (Cannon, 1953). Llinas described these fixed action patterns as "sets of well defined motor patterns, ready made 'motor tapes' . . . that, when switched on, produce well defined and coordinated movements; the escape response, walking, swallowing, the prewired aspects of birdsongs, and the like" (2001, p. 133). Fixed action patterns comprise a variety of simultaneous and sequential movements. When a car appears unexpectedly in our headlights, our adaptive fixed action pattern consists of a variety of movements that enable the fastest defensive action possible: a sudden intake of breath, widening of the eyes, gripping of the steering wheel, slamming on the brakes, and turning the car to avoid a collision.

The evolutionary advantage of these fixed action patterns lies in their automatic engagement, which allows for the development of more complex actions on all levels of information processing. Because we can do them without thinking, fixed action patterns allow us to perform complex tasks automatically, such as walking, and with lightening speed, such as avoiding a deer in the road. Action tendencies are economical and adaptive, leaving the mind free for other tasks (Frijda, 1986; Hobson, 1994; Llinas, 2001; Ratey, 2002; Van der Hart et al., 2006). When we are driving along the highway, we may be thinking about all sorts of things unrelated to driving, while our physical movement mechanically negotiates the complex actions of steering, regulating speed, braking, perceiving other cars/drivers, and so on. If there is danger, our bodies respond without thought to the threat. The speed and automatic nature of fixed action patterns are crucial to survival. It is the recurrence of components of the fixed action patterns as sensorimotor fragments (e.g., intrusive sensations, movement impulses) that reappear after the danger is over that contributes to traumatic reexperiencing.

When the cascade of defensive actions to threat is evoked, some of the actions that constitute an adaptive response may be ineffective, interrupted, or incomplete. An automobile accident victim might have felt the impulse to turn the steering wheel but was unable to execute the action before she hit the oncoming car. The sexual abuse survivor might have wanted to fight

her perpetrator but was overpowered. These incomplete actions of defense subsequently may manifest as chronic symptoms. As Herman noted, "Each component of the ordinary response to danger, having lost its utility, tends to persist in an altered and exaggerated state long after the actual danger is over" (1992, p. 34).

If a person is attacked and experiences the urge to fight back but is overpowered by the attacker, the sequence of possible defensive actions may persist in distorted forms, such as muscles held in a chronically tightened pattern, an exaggerated tendency to be triggered suddenly into aggression, or a chronic lack of tone or sensation in a particular muscle group. Janet gave the example of clients who exhibited symptoms of "contraction of the abductor muscles (the guardians of virginity) brought about by the memory of rape or by that of unwanted sexual relationships" (1925, p. 502). When the components of the defensive response to trauma persist in these altered forms, individuals react inappropriately to perceived threat or reminders of past threat in the present. They may become too aggressive (e.g., the client who turns violent when challenged by his wife) or too passive (e.g., the client, abused as a child, who cannot defend herself from unwanted sexual advances as an adult). Either way, the adaptive execution of a sequence of defensive actions remains truncated, incomplete, and dissatisfying to the individual. Without treatment, these tendencies may indefinitely prevent adaptive action in the present.

Whereas top-down processing is dependent on lower levels, sensorimotor processing can function independently of top-down regulation. During flashbacks or the reliving of past trauma, integrated cognitive processing is inhibited, and the person temporarily loses the capacity to recognize that present reality is safe. Instead, he or she identifies the sensations of hyperarousal and the impulse for physical action as indicators of danger. This bottom-up "hijacking" (Goleman, 1995) is a frequent source of daily life problems and self-blame for trauma survivors: They are unable to reflect on events from a critical distance, which engenders a sense of instability, loss of control, psychological incompetence, and a lack of confidence in coping with daily life. "I should be over this" or "I must be crazy" are two common complaints of traumatized clients, stemming from the conviction that they are psychologically inadequate rather than functioning with sensorimotor systems that are primed for threat and reacting to danger long since over (Allen, 2001).

Cognitive, Emotional, and Sensorimotor Action Tendencies

An action tendency is a propensity to implement or carry out a particular action. Action tendencies are formed on cognitive, emotional, and sensorimotor levels. Tendencies stem from procedural memory of processes and

functions, reflected in habitual responses and conditioned behavior (Schacter, 1996). Procedural learning involves repeated iterations of movements, perceptions, cognitive and emotional processes, or combinations of these (Grigsby & Stevens, 2000). The original events from which these automatic personal processes and routines are learned have usually been forgotten. Actions that are procedurally learned "do not require conscious or unconscious mental representations, images, motivations or ideas to operate" (Grigsby & Stevens, 2000, p. 316). Operating nonconsciously, procedural learning on all three levels of information processing turns into automatic action tendencies that become crucial organizers of behavior.

Long after environmental conditions have changed, we remain in a state of readiness to perform the mental (cognitive and emotional) and sensorimotor actions that were adaptive in the past. For example, the child who learns that it is safer to back away from adults when either she or they are distressed, instead of seeking proximity, might develop action tendencies of avoidance-oriented postural adjustments (turned away, looking at the ground to avoid eye contact), movement impulses that lead to backing away, emotional responses such as fear, and cognitive belief systems such as "It's not safe to seek comfort." These action tendencies "have the character of urges or impulses. They lie in waiting for signs that they can or may be executed; they, and their execution, tend to persist in the face of interruptions; they tend to interrupt other ongoing programs and actions; and they tend to preempt the information processing facilities" (Frijda, 1986, p. 78). In broad terms, an action tendency is a readiness for specific behavior. This "readiness" means that the action tendency exists within the person in latent form and becomes activated in response to specific internal or external stimuli.

Maladaptive actions tendencies conditioned from the past are triggered by internal and environmental reminders of the past and take precedence when other actions might prove more adaptive. Once procedures become automatic tendencies, we no longer use top-down processes to regulate them. Ratey (2002) clarified how this works in terms of the levels of the brain:

> Processes that are fundamental and mastered are stored in and executed from the brainstem, basal ganglia, and cerebellum in the lower brain. Actions and cognition that are increasingly more complex, or very new, are managed further up in the brain, increasingly toward the frontal cortex, so that more brain regions are employed along the way that can offer input or provide delay for consideration. (p. 158)

When working effectively, we can "shift back and forth between deliberate and automatic movements and deliberate and automatic cognition" (Ratey, 2002, p. 160). This capacity is suboptimal for traumatized people, who have difficulty suspending their strong action tendencies to engage in more deliberate, reflective actions (Fonagy et al., 1995).

The Interface Between Top-Down and Bottom-Up Processing

Top-down and bottom-up processing represent two directions of information flow, and their interplay holds significant implications for the occurrence and treatment of trauma. In clinical practice the therapist (1) notices the client's information-processing tendencies on each of the three related yet distinct levels of experience, (2) identifies which level of processing will most successfully support the integration of traumatic experience at any particular moment of therapy, and (3) applies specific techniques that facilitate the processing of traumatic experience at that particular level. For example, consider a survivor of childhood loss and sexual abuse who complains of "feeling unsafe" and simultaneously experiences strong emotions of grief accompanied by trembling and a rapid heart rate. The therapist could choose to use the client's cognitions as an entry point, helping her to use logic to recognize that she is now safe. Or the therapist might decide to deal with the emotions of grief, using interventions that facilitate the client's experience of the unresolved traumatic grief of loss and absence of safety in her childhood. A third option would be to focus on the somatic reactions: The therapist might temporarily disregard the cognitions and emotions and focus exclusively on the physical trembling, accelerated heart rate, and associated movement impulses until they are resolved.

Thus action tendencies on all levels of information processing are viable targets for therapeutic intervention. Any of these entry points would potentially have a positive therapeutic effect. However, it is important to note that the most effective intervention will affect the client not only on the particular level at which the intervention is directed, but also on the other two levels. Changing a cognitive tendency, or belief, can soothe the emotions and the physical experiences; focusing on the emotion of grief can help calm the body and change beliefs; addressing sensorimotor tendencies by tracking physiological arousal until the body settles, or helping the patient explore a previously inhibited physical action, can lower emotional arousal and help shift beliefs.

Psychotherapy has traditionally harnessed top-down techniques to manage disruptive bottom-up processes through the voluntary and conscious sublimation of sensorimotor and emotional tendencies. Such top-down management of arousal is as old as the field of psychology itself and can be an effective therapeutic intervention. When sensorimotor experience is disturbing or overwhelming, conscious top-down regulation can allow a person

to pace him or herself, modulating the degree of arousal or disorganization in the system. For example, a traumatized person who is triggered into high arousal by an innocuous environmental stimulus can manage this arousal by identifying the stimulus as innocuous and reassuring himself until the activation settles. Or he can manage the arousal by engaging in behavior that will distract him, such as watching television, or engaging in behavior that will discharge the arousal, such as going for a jog. Both of these indicate top-down management—deciding cognitively to undertake an activity that takes the edge off the distress associated with an overwhelming experience. The arousal is voluntarily and consciously sublimated through physical activity, behavioral discharge, cognitive override, or mental distraction.

Although top-down distraction or discharge techniques offer effective *management* of hyperarousal and provide significant relief, they may not fully address the entire problem (Allen, 2001), especially the somatic elements. Similarly, changing one's interpretations can engage cognition but ignore sensorimotor processes. Top-down processing alone may manage sensorimotor reactions but may not enable their full assimilation. For instance, a client can learn to mitigate arousal temporarily by convincing herself that the world is now safe, but the underlying tendency for arousal to escalate to overwhelming degrees has not been fully resolved. The traumatic experience and arousal from the sensorimotor and emotional levels may be redirected through top-down management, but the processing and assimilation of sensorimotor reactions to the trauma may not have occurred.

In sensorimotor psychotherapy, top-down direction is harnessed to support sensorimotor processing rather than just manage it. The client might be asked to mindfully track (a top-down, cognitive process) the sequence of physical sensations and impulses (sensorimotor process) as they progress through the body, and to temporarily disregard emotions and thoughts that arise, until the bodily sensations and impulses resolve to a point of rest and stabilization. In much the same way that a client who comes to therapy with unresolved grief can identify and experience the grief (emotional processing), a client who exhibits unresolved sensorimotor reactions can identify and experience these reactions *physically* (bottom-up sensorimotor processing). The client learns to observe and follow the sensorimotor reactions that were activated at the time of the trauma, as well as to mindfully execute physical actions that interrupt maladaptive tendencies.

Conclusion

Optimal functioning of the higher levels of the brain and of information processing is dependent, to some degree, upon the adequate functioning of the lower levels. There are extensive interconnections among all parts of the

brain and among all levels of information processing. Ratey noted that "when we smile we feel happier and when we feel happier we smile. . . . The feedback between layers or levels of the brain is bidirectional; if you activate a lower level, you will be priming an upper level, and if you activate a higher level, you will be priming a lower level" (Ratey, 2002, p. 164). The client's awareness and processing of sensorimotor reactions exert a positive influence on emotional and cognitive processing, and vice versa. Movement and body sensation, as well as thoughts and emotions, are viable targets for intervention that can support resolution of the traumatic experience. Top-down approaches that attempt to regulate overwhelming sensorimotor and affective processes are a necessary part of trauma therapy; but if such interventions overmanage, ignore, suppress, or fail to support adaptive body processes, these traumatic responses may not be resolved. Similarly, bottom-up interventions that result in bottom-up hijacking, or fail to include cognitive and emotional processing, can sabotage integration and may lead to endless repetitive flashbacks, secondary retraumatization, or chronic trauma kindling (Post, Weiss, Smith, Li, & McCann, 1997). In order to treat the effects of trauma on all three levels of processing, somatically informed top-down management of symptoms, insight and understanding, and bottom-up processing of the sensations, arousal, movement, and emotions must be thoughtfully balanced.