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# Neurobiology and the Changing Face of Eating Disorder Treatment: Healing the Eating Disordered Brain

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Additional information is available at the end of the chapter

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## Abstract

By recognizing eating disorders (EDs) as disruptions in brain circuitry, neuroscience has begun to shed light on *how* people make changes in psychotherapy. The clinician who treats the eating disordered patient also treats the eating disordered brain. It is time for practitioners to become better acquainted with the organ they treat, and to apply neuroplasticity research findings to clinical practice. Eating disorders and body image disturbances signify the loss of integrity of the core self. Twenty-first century research and technology has validated the age-old notion that healthy neuronal connectivity within, and between, mind(s), brain(s), and body(s) reintegrates and defines the healthy self. The concept of the “self” as *embodied* (grounded in somatic reality) expands the scope of effective healing practices. Neurophysiological (somatosensory education and mindful psychotherapeutic attachments) interventions that support the emergence of embodied mindfulness and sensory awareness facilitate the reintegration of the eating disordered brain, and of the fragmented core self. Both lie at the heart of eating disorder recovery. Nowhere in the field of mental health are the concepts of the embedded self and embodied healing as significant as in the treatment of eating disorders and body image disturbances. This article discusses the healing impact of neurophysiological connections, intrapersonal and interpersonal, that foster recovery of the self.

**Keywords:** eating disorders, neurobiology, somatosensory interventions, somatic education, Feldenkrais method, neuroplasticity, neurophysiological treatment modalities, mindfulness in psychotherapy, neuronal connectivity, modern attachment theory, embodied brain, body image, self integration, neuro-cognitive retraining, trauma treatment, eating disorder recovery

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“It is around the concept of the core self that psychology crosses paths with the brain and body” [1].

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## 1. Eating disorders in the “Era of the Brain”

Eating disorders (EDs) are bio-psychosocial disorders, their origins and functional pathology based in genetics and brain structure. In the year 2006, by declaring anorexia nervosa (AN) and bulimia nervosa (BN) to be disorders of the brain, Thomas Insel, of the National Institute of Mental Health (NIMH), changed the face of ED treatment forever. “There is good reason to think that the prefrontal cortex is the brain center for some eating disorders, obsessions, addictive disorders, and alterations of body image” [2]. Studies show “substantial evidence that individuals who exhibit (ED) pathology are “wired” differently, ...creating the need to define diagnosis by aberrations in brain circuitry and physiology, and then provide treatments aimed at correcting or ameliorating the aberrant circuitry” [3]. “The days of being able to talk about psychology versus biology versus neurology are fading” [2]. The NIMH initiative has not only set the stage for changes in the philosophical and clinical underpinnings of ED treatment, but also for the future of scientific research in this field. The advent of positron emission tomography (PET) scans and other neuroimaging devices capable of tracking and recording even the smallest brain changes has shed significant light on *how* people make changes in psychotherapy.

It is the functional linkage (integration) of differentiated components of a system that defines efficiency in function and well-being. “Unity within the human nervous system creates coherence, fluidity and flexibility, otherwise known as maturity. Lack of integration between spheres leads to chaos, or system rigidity” [4]. “Within psychotherapy, the focus of attention on various domains of mental, somatic, and interpersonal life creates neural firing patterns in the brain that enable new synaptic connections to be established [4]. In fact, neuronal plasticity, the changes in neural connectivity induced by experience that integrates brain function, may be the fundamental way in which psychotherapy alters the brain” [5]. Studies have shown that the more successful the (therapeutic) treatment, the greater the neuroplastic change [6]. Effective psychotherapeutic interventions “awaken” the patient's brain to attention, inviting and inspiring it to integrate learning through intrapersonal, as well as interpersonal, connections. Neuronal changes that occur over the course of an engagement between therapist and patient, when they take the form of a true “meeting of the minds,” promote self-regulation [5]. The broad and integrative goals of ED recovery, which encompass emotional, physiological, neurophysiological, cognitive and social development, are best met through diverse and integrative recovery interventions, which hold the potential to facilitate a range of quantifiable changes in brain structure and function.

A brain that “marinates” in ED habits and patterns over years, and sometimes decades, will incorporate ED pathology into its structure as well as function. There is, however, a tremendous capacity for self-correction built into the human nervous system. “The brain is so plastic and changeable that alterations are not only possible, but *inevitable*. Unmasking, exposing, and strengthening secondary neural pathways are one of the main ways the plastic brain reorganizes itself” [6]. “When ‘weak links in the chain’ are strengthened, (through neural integration within and between regions) people gain access to skills whose development was formerly blocked. As a result, they feel enormously liberated” [6].

Quantitative neurophysiological studies across disciplines such as kinesthesiology and somatic education reveal treatment principles and interventions that support neuroplastic

changes at the brain level. Though relevant to ED recovery, the regrettable absence of these studies from the ED literature has made them essentially inaccessible to ED practitioners, rendering potentially beneficial outcomes lost to current mainstream ED clinical practice. Incorporating adjunctive neurophysiological treatment interventions into ED clinical practice would bridge the current research/practice chasm, facilitating brain and body integration and enhancing the healing of the ED *brain*, along with the ED patient.

## 2. Anorexia nervosa (AN) and bulimia nervosa (BN) are disorders of the brain

### 2.1. Genetic and trait-related characteristics of eating disorders

Emerging evidence suggests that both AN and BN are familial disorders, and that the clustering of these disorders in families may arise partly from genetic transmission of risk [7, 8]. A study suggests a common familial transmission of AN and obsessive-compulsive personality disorder, and the existence of a broad, genetically influenced phenotype with core features of rigid perfectionism and propensity for extreme behavioral constraint [9]. “Abnormalities in systems relevant to reward processing and the development of habit systems (in AN) have been consistently described within this population in structural and functional neuroimaging studies. Some aspects of dieting behavior are initially rewarding, but this behavior persists in individuals with AN as maladaptive behavior because it is ultimately mediated by neuronal circuits linked to habit formation” [10]. The postrecovery disturbance of such behaviors as a drive for thinness, over-concern with body shape and weight, obsessional behavior, dysphoric mood, etc., gives rise to the question of whether these elements, too, might be premorbid traits contributing to the pathogenesis of AN and BN [9].

The fact that recovered anorexic patients suffer from cognitive flexibility impairment also suggests that this is not a temporary state due to starvation, but a characteristic trait [11]. Functional MRI studies of AN demonstrate that “impaired cognitive-behavior flexibility causes behavioral rigidity which leads to maintenance of symptoms and resistance to treatment. The suppression of alternative behavior emanates from the diminished activation of a certain network pathway between the cortex and the diencephalon (that) plays a decisive role in initiating and controlling actions under rapidly changing environmental demands” [12]. Studies show that cognitive impairment in AN involves visuospatial ability, attention, memory, and cognitive flexibility [11].

A study that addresses persistent body image disturbances following ED recovery suggests an imbalance between internal and external representations of the body as a trait feature of ED, rather than just a feature of the acute state. Individuals with a lifetime history of an ED may have heightened sensitivity to visual information about the body and reduced somatosensory information processing of the body [13]. This suggests “an altered capacity of anorexic patients in processing and integration of bodily signals. Body parts are experienced as dissociated from their holistic and perceptive dimensions. Specifically, it is likely that not only perception but memory, and in particular sensorimotor/proprioceptive memory, shapes bodily experience in patients with AN” [14]. According to Norman Doidge, “because we see

(perceive) with our brains and not with our eyes, the plastic brain becomes capable of reorganizing its sensory-perceptual system and with it, potentially our body image. We perceive ourselves—what we look like and feel like—with a perception that exceeds vision” [6]. It has been proposed that “restoring the balance between internal and external/visual information about the body by increasing interoceptive and/or proprioceptive awareness through sensory (neurophysiological) training should produce a less malleable and more accurate body perception. Multisensory impairment, which involves tactile and proprioceptive sensory components that may be associated with parietal cortex alterations, can best be treated through multisensory therapies” [13].

Research suggests that the altered function of neural circuitry contributes to restrictive eating in AN, and overeating in BN. “A clear link exists between AN and neural processes in the insula cortex as an integral part of ED pathology. The insula, which monitors bodily sensations and the strength of responsiveness to them, is the region where taste is sensed and integrated with reward to help determine whether an individual feels hungry or full” [15]. Identifying abnormal neural substrates could hold important implications for treatment through reformulating the basic pathology of ED and offering new targets for treatment. As an example, it may be possible to modulate the experience by enhancing insula activity in individuals with AN, or dampening the exaggerated or unstable response to food in those with BN [15]. Four separate regions within the insula cortex have been found to connect to social-emotional, sensorimotor, olfacto-gustatory, and cognitive networks of the brain. Functional systems overlapping within the insula reflect a possible linkage between them “necessary to integrate different qualities into a coherent experience of the world, setting the context for thoughts and actions” [16].

## 2.2. Neurological effects of ED on child and adolescent brains

The onset of AN in the developing brains of children and adolescents put young patients at risk for serious neurophysiological dysfunction. Studies show that low weight and higher cortisol levels correlate with greater structural brain abnormalities [17]. The brain's neuronal pathways multiply at a prodigious rate from birth to 6 years of age through the proliferation of gray matter, attaining 90–95% of adult brain growth. From age 6 to 12, neuronal pathways increase interneuronal connectivity, through the thickening of gray matter. Cerebral atrophy has been noted in cases of enduring AN, leading to what was initially considered to be an irreversible reduction in gray matter volume [17]. Follow up studies show that “the main brain changes seem to be reversible to some extent after adequate weight restoration, with brain changes in BN seemingly less pronounced than in AN, mainly due to chronic dietary restrictions” [18]. It is important to note, “though weight recovery may lead to the normalization of *structural* brain abnormality in ED patients, [18] weight restoration alone may be insufficient to fully rectify a nutritional insult. Adequate body composition and healthy hormonal function is also required to support optimal brain *function* in an ‘all systems go’ neuro-endocrine environment” [17].

The new diagnosis of ‘avoidant/restrictive food intake disorder’ (ARFID) has taken the place of ‘feeding disorder of infancy and early childhood’ in the American Psychiatric Association's Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition [19]. Though not all children who experience picky eating syndrome meet the criteria for the ARFID diagnosis, one study found that, at any age, between 13 and 22 percent of children

were reported to be picky eaters [20]. Prevalence rates for picky eating ranges from 14 to 50 percent in preschool children and 7 to 27 percent in older children [20]. ARFID patients tend to be younger than those with AN or BN, include a higher proportion of males, and are commonly diagnosed with comorbid psychiatric and/or medical symptoms [21]. Many suffer from sensory integration disorder. Though evidence-based research has not yet proven the origins of ARFID, or of picky eating, to be in neurophysiology, tactile defensiveness and heritable factors such as variations of a specific tasting gene (dubbed TAS2R38) have shown up in “sensitive tasters, “who report that for them, vegetables take on an intolerable metallic taste. How bitter something tastes has to do with how tightly the bitter compound in foods binds with bitter receptors on the tongue” [22]. Currently, there are very few curative resources for picky eating individuals, both young and old, many of whom restrict themselves to eating no more than 5 to 15 foods. Existing solutions are based on behavioral exposure, desensitization and extinction therapy, and occupational and speech therapy, none of which have been shown to be uniformly successful. Considering the neuroplastic healing capacity of the brain, one might predict that the neurophysiological nature of this diagnosis could eventually find remediation within neurophysiological (somatosensory-based) interventions.

### **3. Human experience facilitates brain development**

Historically, we tend to think of learning as initiated internally, within the cranial brain, but this is only partly the case. Learning also occurs externally, through the experience of movement, sensation and behavior, which create neuronal networks “from the outside, in,” and from “bottom up.” The nervous system's brain resides not solely in the cranium, (where learning happens “top down”) but in the body. The embodied brain's sensory receptors send neuronal messages through the spinal cord to sensory receptors within the cranial-based brain. Human experience of all kinds stimulates and strengthens the formation of new and diversified neuronal pathways, guiding intelligence and instinct. “Synaptic linkages created by a combination of genes and experience shape new connections among neurons, dependent upon how genes are activated, proteins produced, and interconnections established within the neural system” [5]. The process of learning “affects which genes in our neurons are transcribed, shaping our brain's microscopic anatomy” [6]. Neuroscientist Michael Merzenich contends that practicing a new skill, under the right conditions can change hundreds of millions, and possibly billions of connections between the nerve cells in our brain maps, which develop strong connections to one another when activated at the same time. The potential for neuroplastic brain change remains viable throughout the human life span, with maps of normal body parts changing every few weeks through reorganization that occurs within and across brain sectors [6].

#### **3.1. Awareness and attention facilitate brain integration and learning**

A unified core self and feelings of well-being emerge out of a healthy integration of neurophysiological inter-relationships between moving, thinking, feeling, and sensing, and can be enhanced through mindful human connection. Any therapeutic learning experience with

the capacity to move an individual towards balance, past negative habits, and closer to healing, promotes an integration and reestablishment of the once fragmented ED self. The human brain learns organically. “Organic learning is nonreductionistic, and therefore integrative, not separating the organism into its anatomical parts, but joining those parts into one continuous feedback loop [23]. The human brain's feedback loop contains the sensory domain, the motor domain, the affective domain, the cognitive, and spiritual domains, building on dimensions such as pleasure and spontaneity” [6]. Interventions that upgrade and integrate global brain function and increase neuronal connections and networks, brain weight, volume and thickness, and the number of branches among neurons, come about through focused attention, discernment, differentiation, and integration [6]. The following is an example of how the brain learns through focused attention (awareness), variation (change and novelty), differentiation (the capacity to sense and create differences,) and integration (the capacity to bring the learning to a meaningful coherence).

As an example, my 2-year-old grandson was thoroughly enjoying the attention he craved from disrupting the family dinner by kicking his shoes against his highchair. His brain sought stimulation, so I suggested that he kick the chair as loudly and as fast and hard as he possibly could. He enjoyed this experiment immensely. Then I suggested that he try to use his legs and brain differently, to kick the chair as slowly and as softly as he possibly could, seeing if he could make the sound so soft that no one else at the table would know that he was even moving his feet. In offering his brain this opportunity for attention, variation, and sensory discernment, this became not only an exercise in learning about loud and soft, fast and slow, hard and gentle, but in experiencing expansive new perspectives about how to use himself in moving towards self-regulation, self-determination, and self-satisfaction.

According to Moshe Feldenkrais, a pioneer in the field of somatic education, within the process of learning, “the more completely a person accesses and uses his entire muscular apparatus, the more the brain will become activated, with the activated regions further stimulating adjacent areas” [24]. The novelty of diverse types of therapeutic interventions stimulates different regions of the brain in facilitating connections between neurons [6].

The feedback loop of the *eating disordered* brain sustains biochemical, neuromuscular, and sensory imbalances resulting in the *disintegration* of the core self. Compensatory behavioral compulsions and dysfunctional eating rituals lead to erratic weight gain or loss, amenorrhea, bradycardia, and electrolyte imbalances. Resulting mood shifts compromise the patient's capacity for self-regulation and self-care, exacerbating behavioral pathology and physiological dysfunction. The at-risk eating disordered child who is developmentally unprepared to cope with the complexities of treatment and recovery tasks becomes most deeply vulnerable to the dire emotional, physical, and neurophysiological complications of these disorders. Diminishing cognitive, perceptual, emotional, and sensory acuity compromises a patient's capacity to benefit from psychotherapy.

### **3.2. Interventions that facilitate sensory connectivity promote self-integration**

EDs are disorders of sensing. ED patients experience an impaired capacity to accurately sense, process and integrate bodily signals. “What emerges as the core experience of recovery is

the process of re-establishing a sense of self, where the word “sense” is as important as the word “self” [25]. What ED individuals *do* sense, typically, are feelings of isolation, shame, and self-loathing. ED patients experience difficulty in accurately sensing/perceiving hunger and satiety cues. For those with co-occurring mood disorders, the impulse to inflict self-harm may serve as an attempt to reconnect, through sensation, with the lost self. Sensory integration can occur through neurophysiological connections *within* the cranial brain; *between* the skull-based and body-based nervous system in the context of somatosensory, kinesthetic experience; through technological, non-invasive interventions; and through empathic and mindful psychotherapeutic attachments within psychotherapy.

The fact that “self-organization of the developing brain occurs in the context of a relationship with another being, another brain, renders psychotherapy a potentially powerful neuroplastic treatment tool” [26]. Schore defines psychotherapy as an attachment relationship that affects underlying neuronal structure and function” [26]. It is the ever-deepening sensation of connection between the therapist and patient that evokes an ever deepening sense of the patient’s trust in herself. Emerging self-trust fortifies the patient to face and withstand the challenges and frustrations implicit within the ED recovery process, as well as in life itself, without the false security of the ED “crutch.”

In treating eating disorders, various forms of adjunctive sensory training interventions are meant to augment, not replace more traditional mainstream approaches to ED treatment, known to promote the achievement of the “core principles” of ED recovery. The core principles of recovery include: (1) changes in the neuro-biological context, to include nutritional rehabilitation, weight normalization and stability, with no compensatory symptom substitution for the interruption of dysfunctional behaviors, (2) treating psychiatric comorbidities to remission, (3) addressing external environmental changes, and (4) connecting to maintenance factors for recovery [17].

#### **4. Mindfulness practice within the psychotherapeutic relationship promotes the integration of brain and self**

“Healthy human attachment and mindful connectedness that results in the patient feeling “felt” through a versatile treatment relationship, creates a state of neural activation with coherence in the moment that has been shown to improve the patient’s capacity for self-regulation” [5]. Within the mindful relationship, the quality of awareness and attention is broad and open, devoid of expectation, and biasing perceptual filters. The mindful quality of a treatment relationship, which has been defined as “paying attention in a particular way...on purpose, in the present moment, and non-judgmentally,” [5] can be considered an intervention in itself [27]. “Two aware minds are more powerful than only one aware mind” [28]. Germer contends that mindfulness and the quality of the therapy alliance that arises from it “is more important to treatment outcomes than the particular treatment method or theory embraced by the therapist” [27]. “Empathy accounts for as much, and probably more, outcome variance than does the specific intervention. The mindful connection “may be even more influential in intervention-based treatment than in relational-based therapy” [27].



Mindfulness and empathy in psychotherapy demands the therapist's ongoing "presence" within the treatment moment, a state of "being aware, in a receptive way, of what is happening as it happens" [29]. It is the state of being present that allows a person to thrive within the experience of uncertainty [29]. Conversely, it is the *intolerance* of uncertainty that drives the patient's relentless resistance to letting go of an ED, which seductively guarantees predictability in life by providing the illusion of control over self and future. Mindful practice allows patients "to feel less resistant to, and threatened by, the vicissitudes of life experience through an acceptance of self and reality, allowing a greater capacity to choose whether to act on one's urges," [27] a concept particularly relevant to the treatment of BN and binge eating disorder (BED), which are characterized by impulsivity and self-disregulation. The fact that our intention to act is formulated in the brain *before* we become aware of it suggests that we may be able to change the brain through mindfulness practice. The individual has an opportunity to better control behavior by increasing mindful awareness of brain activity [27].

The promotion of the patient's brain integration and self-integration is a natural by-product of accepting awareness of both pleasant and unpleasant inner experience (body sensations, affects, and/or thoughts) [28]. The process of achieving mindful presence starts with a focus on bodily sensations that are connected to the issues the client brings to the therapy process, and that involve attention to body-felt experience from which other elements of subjective experience arise (emotions, cognitions, memories, etc.) [27]. It is in the state of "being present" that embodied psychotherapeutic change takes place, and where, in the end, neurons become altered, changing brain function and structure [29]. Mindfulness training has been shown to be associated with changes in gray matter concentration in brain regions involved in learning and memory processes, emotional regulation, self-referential processing, and perspective taking [30]. "Ultimately, lasting effects of psychotherapy need to harness experiences that promote the growth of new synaptic connections so that more adaptive capacities for self-regulation and well-being can be established" [5].

The mindful patient who becomes able to reject an obsessive focus in the past in order to rethink and recreate the course and flow of the present, positively affects his or her future by stimulating neurophysiological brain changes. Enabling mindfulness by creating an ongoing awareness of the patient's positive changes throughout recovery revives forgotten sensations of successful achievement, allowing the patient to *recapture* the benefits of the new circuitry that has been laid down.

Consider this example. A highly functioning woman recovering from 10 years of AN, periodically experiences herself as a failure in all her life roles, as a wife and mother, in her work, and as a recovering patient. By inviting her to join me in recalling, revisiting, and recounting the positive life experiences that she had incurred throughout her treatment, she became increasingly able to "piggy-back" on previous successes. By re-stimulating and/or simulating the previously felt sensation of confidence in anticipating novel experiences, (a process known as "faking it till you make it") she began to feel herself empowered by new neuronal pathways, having been laid down and now deepening.

Mindfulness is a revolutionary concept for psychotherapy, a profession that has traditionally seen movement and mental processes as separate processes. In offering a more unified model

of psychotherapy, mindfulness in clinical practice has proved to be “a teachable construct that draws clinical theory, research, and practice closer together” and that may prove to be “a tangible means for building empirically supported relationship skills” [27]. Mindfulness strategies in psychotherapy, which cultivate moment-to-moment awareness as a curative mechanism, serve most forms of psychotherapy across the board.

#### **4.1. Clinical applications of mindfulness within ED treatment**

##### *4.1.1. Facilitating learning through mindful neurophysiological interventions in hospital settings*

Though we tend to think of mindfulness as originating from the “top down” through the functioning of mind, mentality and cognition, mindful kinesthetic and bodily-based activities are also capable of evoking significant learning and healing from the “bottom up.” In highlighting and addressing the ED patient's reluctance to experience herself in novel problem-solving situations, a partial hospital program assigned its adolescent patients three neurophysiologically-based tasks, designed to reinforce new sensations and learning through somatosensory movement. These included writing a sentence with one's unaccustomed hand; observing oneself in the act of walking backwards; and drawing a picture with one's eyes closed. Teaching potent lessons, these experiences challenged the patient's self-awareness and fear of the unknown, failure in the eyes of others, and the sensation of being unprepared and out of control.

When asked to discuss their responses to these tasks, the patients described feeling frightened, initially, about using themselves in unaccustomed ways. Following these experiences, they expressed surprise at how much they had improved at each task through engagement and continued practice, how helpful it had been to receive support from their peers in the process, how much they had learned from listening to each other's experiences, how acceptable it had seemed to try, and to fail, at new things, etc., all metaphors for ED recovery, and for life itself. No purely cognitive experience could have accomplished what these experiences provided these youngsters, so quickly and so potently.

Facility-based psychodrama therapy groups offer patients a liberating sense of permission to confront their “virtual” ED through community-based dramatic performances of confrontational dialogues with their disorder. Face to face with the ED and oneself, the patient's experience of expressing feelings within the context of a supportive peer and professional community tends to be a cathartic and gratifying experience among ED group populations.

Patient re-feeding becomes a pivotal soma-physiologic learning process that occurs within hospital, residential, or intensive outpatient settings. In such instances, the embodied brain comes to understand the reality that, in being required to restore weight, the body can, and will, consume goodly amounts of nutritious foods at regular intervals without becoming obese. A major concern of recovering ED patients tends to be draconian weight gain through an imagined loss of self-control upon ingesting normal amounts of food. Weight gain can be gradual and self-regulated, representing a pivotal lesson taught by the body in its wisdom.

*A disregulated 14-year-old bingeing-type anorexic female who alternated bingeing and starvation, described her one-month experience of treatment in an outpatient treatment facility. She reported, “It wasn't till I had a chance to be fed at the program that I was finally able to understand that I can eat*

*healthfully without getting fat ... I did it there, I know what it is like, and now I have felt what it feels like to have food in my stomach without panicking. My stomach actually became comfortable having food in it after a while, and I learned that I can choose to put it there through the decisions I make. I get hungry for meals now, without becoming frightened, and am beginning to understand what it feels like to have a normal relationship with food." This patient's bodily experience, autonomously and experientially allowed her to integrate, own, and utilize previously disintegrated cognitive and behavioral attempts to alter her eating lifestyle, this time more successfully.*

Upon release from the program, this youngster no longer engaged in bingeing and starving behaviors. She had become capable of eating normally and without fear, having developed new trust in her body and self. Fully prepared now to engage in the psychotherapy process, she set about to resolve the deeper emotional issues driving her disorder.

#### *4.1.2. Mindfulness has emerged as an important focus of inpatient and outpatient treatment techniques for ED*

Dialectical behavior therapy (DBT), cognitive behavioral therapy (CBT), and acceptance and commitment therapy (ACT) treatment techniques and strategies are designed to systematically ameliorate distortion in the patient's cognition, self-perception, coping, and problem-solving skills through mindfulness skills, which include emotional regulation, distress tolerance, and interpersonal effectiveness. Dialectical behavior therapy is a mindfulness-based cognitive behavioral methodology, particularly effective in the treatment of co-occurring depression, stress reduction, and borderline personality disorder. Mindfulness in DBT evokes a quality of awareness that allows one to control the mind, so the mind ceases to control the person. The roots of DBT mindfulness practice are in the benefits of "allowing," or accepting experiences, rather than suppressing or avoiding them. By reducing the anxiety that deters learning, mindfulness informs cognition, bringing the protocols of CBT into a dynamic mechanism for change" [27].

The recent advent of the inclusion of mindfulness in cognitive behavioral therapy, known as mindfulness-based cognitive therapy (MBCT) combines cognitive behavioral therapy with meditative practices and attitudes. The assignment of behavioral tasks to counteract habitual, ritualistic, and entrenched thoughts and behaviors creates new neuronal pathways in the recovering brain. ACT is a branch of cognitive therapy that acknowledges the centrality of the therapy relationship, achieving successful outcomes through mindfulness strategies coupled with commitment and behavioral change strategies. The goal of ACT is to foster emotional flexibility, emotional integration, and emotional maturity. ACT focuses on full acceptance of present experience, and mindfully letting go of obstacles, as patients identify and pursue their life goals.

## **4.2. The neurophysiology of effective attachment in mindful therapeutic relationships**

It is through the relationship that "deficits in internal working models of the self and the world are gradually repaired" [26]. Schore's developmental model places particular emphasis upon "the experience-dependent maturation of a system in the orbital prefrontal cortex that regulates psychophysiological state and organismic energy balance. This frontolimbic system is expanded in the nonlinear right hemisphere that generates

stress-regulating coping strategies..." [31]. "The healing impact of the therapeutic relationship occurs through transactions where "the sensitive empathic clinician's monitoring of unconscious process, rather than content, calls for right brain attention to matching the patient's implicit affective-arousal states" [32]. By means of reverie and intuition, the therapist listens with the right brain directly to the patient's right brain [32]. Implicit right brain to right brain intersubjective transactions lie at the core of the therapeutic relationship, mediating the "moments of meeting" between patient and therapist. The right brain to right brain hemisphere connection that exists "outside our skin," gives rise to a therapy relationship so deeply ensconced in psychophysiology as to be considered sharing a common brain, "a mind being changed by a mind" [32].

Paralleling this dynamic, the infant's early emotional interactions with the primary object facilitate the neurophysiological development of the child's right brain. The attachment dynamics in psychotherapy between the therapist and patient, too, have been shown to result in learning that regulates psychobiological states of emotions. The aspects of "good parenting" that therapists offer patients become more than a metaphor, with the roots of the therapy relationship deeply ensconced in brain-related psychophysiology.

The implicit realm of communication is enhanced when the therapist is in his own enhanced state of right brain receptivity. The therapist's openness to his own bodily state is a crucial first step in establishing the interpersonal attunement and understanding that is at the heart of interpersonal integration and self-regulation. "By accessing his own neurophysiological responses to the patient's communications, the therapist's right brain connection allows him to know the patient "from inside out" [32]. "Where the therapist is sensitive to the patient's signals and also has made sense of his or her own life, the state of brain activation in the therapist serves as a vital source of resonance that can profoundly alter the ways in which the patient's brain is activated in the moment-to-moment experiences within therapy" [5]. The subconscious processing of information uses an expansive attention mechanism on the part of the therapist that includes free association, while the left brain remains more involved in the conscious processing of information, using a more restricted mode that focuses on local detail" [32]. In monitoring countertransferential responses, the clinician's right brain tracks at a preconscious level, not only the arousal rhythms and flows of the patient's affective states, but also his own interoceptive bodily-based affective responses to the patient's implicit facial, gestural, and prosodic communications" [32].

"As an interactive regulator of the patient's psychological states," [31] the therapist's emotional involvement offers a deep, fearless, and well-boundaried being. Attempting to achieve an open, receptive state of awareness of internal state changes and interpersonal signals sent by the patient, the mindful therapist who has learned to identify and disentangle his own thoughts and feelings inspires the patient to develop the same skills and insights that *he* has developed in approaching life. Sharing a common ground, therapist and client experience and discover each other from a position of equality" [27]. "Where therapists are not intimidated, and when they can feel comfortable disclosing themselves in appropriate, boundaried, and clear intentional ways, patients are offered the opportunity to bring forward more of their *own* seemingly intolerable experience. Our receptivity assures patients that they need

not censor themselves, so that difficult emotions lose some of their threat. Resonance, or perceptions of another's affective expressions, may alter our own somatic and limbic states as practitioners. By accessing one's own bodily-based intuitive responses to the patient's communications, the intersubjective field between two individuals includes far more than two minds, to include two bodies" [32]. Significant to ED treatment, in light of the body image concerns of ED patients, "The right brain hemisphere contains the most comprehensive and integrated map of the body state available to the brain" [33].

#### 4.2.1. *The talking connection in psychotherapy is an embodied connection*

Siegel describes the mind as relational, as well as embodied. According to him, "The mind uses the brain to create itself through the process of neuroplasticity... in turn, the functioning of the mind can actually change the structure of the brain itself" [34]. Through mindful psychotherapeutic connections, talk therapy resonates, brain to brain, as an embodied function. "When the therapist's mind and embodied self come together in relationship with those of the patient, implicit systems of the therapist interact with implicit systems of the patient, rendering psychotherapy not the "talking" cure, but the "communicating" cure" [6]. Psychiatrist Dr. Susan Vaughan has argued that the talking cure works by "talking to neurons," and that an effective psychotherapist or psychoanalyst is a "microsurgeon of the mind" who helps patients make needed alterations in neuronal networks" [6]. "The aim of talking cure... from the neurobiological point of view (is) to extend the functional sphere of influence of the prefrontal lobes" [6]. "Psychotherapy works by going deep into the brain and its neurons and changing their structure by turning on the right genes" [6].

Brain scans have shown that "talk therapy can change the brain even in a state of severe OCD brain-lock." Jeffrey M. Schwartz theorized, then proved, that patients could shift the brain "manually" by paying constant effortful attention and actively focusing on something besides the worry, such as pleasurable activity, proving that what a patient *feels* is less important than what he *does*. Schwartz found that changes in the brain from mindful cognitive (talk) therapy can be similar to those from psychoactive medication" [27].

## 5. The ED, the brain, and the self are dynamic processes on the move

According to Albert Einstein, "Until something moves, nothing happens." The cohesion of movement and sensing plays an extensive role in how the nervous system coordinates a coherent sense of self [1]. Until the mid-twentieth century, scientists believed that the brain was "hard-wired" and unchanging, and that humans were born with a predestined potential, as well as limitations. Neuroplasticity research that began in the late 1960s and early 1970s overturned the doctrine of the unchanging brain, demonstrating that the brain changes its structure with each different activity it performs, continually perfecting its circuits so as to be better suited to any task at hand. The formation of neuronal pathways carved from deeply rutted habituated behaviors within the human brain is in some respects similar to rivers and streams carving their pathways through rock. The malleable and efficient

brain develops and augments enriched networks of neuronal “tributaries, estuaries, and tide pools” through altering the direction, speed, and flow of learning. Moshe Feldenkrais contended, “Without movement there is no life [24].” He described the self as “never static... changing from action to action” [24]. Eating disorders, too, are on the move; never static, if not actively healing, they are actively securing a more profound and pernicious foothold within the patient's brain.

“Set off by a dynamic flow of electrochemical energy that creates electrical signals and patterns inside neurons, neoplastic learning and change occurs through the movement of ions in and out of brain membranes. “All experiences encompassing thought, sensation, feeling, and behavior, be it conscious or unconscious, are embedded in neurons. When movement occurs within neuropathways, the “language” of growth and change consists solely of the movement of electrical patterns along the neuropathways in the brain's cortex, as there are no visual images, sounds, smells, or feelings moving inside our neurons” [6]. Hebb proposed that “learning links neurons;” that when two neurons fire at the same time, (or when one fires causing the other to fire) chemical changes occur in both, so that the two connect more strongly. The neuroscientist Carla Shatz summarized the concept: “neurons that fire together, wire together” [6]. The more often the respective neurons “talk” to each other, “the greater the capacity for learning to become solidified” [6].

Brain-changing electrical movements originate either in externalized behaviors, through experience and behaviors, affecting the brain “from the outside in,” or through thoughts, ideas, and feelings, “from the inside out” [6]. The brain changes its structure and function with each different activity it performs, continually perfecting its circuits so as to be better suited to any task at hand. According to Feldenkrais, “so smart is the human brain, that learning to do something with ease and facility once, can be sufficient to bring about change even after the brain has done that thing ineffectively a thousand times.” If one “part” of the brain fails, than other parts can take over... if brain cells die, they can at times be replaced, or other parts can be recruited to take over their function [35].

### **5.1. Movement *with attention* facilitates learning**

Where attention goes, neural firing occurs, and where neurons fire, new connections can be made. In this manner, “learning a new way to pay attention within the integration of consciousness enables the client with an open receptive mind to catalyze the integration of new combinations of previously isolated segments of his or her mental reality” [5]. “The repetition of novel, ameliorative behaviors alter neuronal pathways within the structure of the brain by “shaping” or “training,” “molding new behaviors in very small steps [6]. In treating an obese individual who suffered from compulsive over-eating, Feldenkrais assigned her the daily task of slowly and mindfully counting every spoonful of cereal with milk that she puts into her mouth throughout the day. “The client's mindful self-monitored attention to the reality of the current moment cultivates an awareness of what has worked in the past, affecting what might work in the present, and what might be worth trying in the future” [27].

Rote, mindless, and undifferentiated movement, such as the mechanical repetition of an action through repetitive exercise, will not produce self-image change. Clarifying the self-image

requires the reshaping of neurocircuits through self-awareness, with mindfulness of each part of the action, the patient's experience during the action, and the perception of the total body image during and following the action [36]. Attention paid to behavior has been deemed, "the specificity scalpel into the brain to recarve neurocircuits" [34].

## **5.2. The healthy mind, body and self weave a fabric of unified connection**

Scientific evidence of the unity of mind and body in defining the healthy self has validated 2500 years of Buddhist thought and practice. Brain research points to a dynamic, experientially based notion of the healthy self as an embodied, sensory-based process grounded in kinesthetic experience [5]. The healthy "self" is a wholly integrative fabric with no one element separated from any other, the product of a neurophysiological inter-relationship between moving, thinking, feeling, and sensing. Sigmund Freud and Moshe Feldenkrais saw the unity of mind and body as an objective reality. Asserting that there is no valid distinction to be made between them, Feldenkrais observed that without a change in muscular habits of action, a person in Freudian psychoanalysis would often revert back to a habitual way of acting even when their therapeutic insights should have helped them change their behavior [6].

During 1940s, he postulated that "emotions are themselves body phenomena. We cannot be conscious of a feeling before it is expressed by a motor mobilization...They are not two states but two aspects of the same state" [37]. Toole describes body awareness as a "doorway into inner space" and an "awakening of consciousness" which "counteracts the loss of self in thinking, in emotions, or in external situations" [38]. He contends that primarily identifying with the mind to the exclusion of the body creates "an opaque screen of concepts, labels, images, words, judgments, and definitions" capable of blocking "a sense of oneness," the relationship between man and himself" [39]. In other words, the mind is embodied, built in part from roots in somatic reality" [5].

Twenty-first century magnetic resonance imaging (MRI) offers scientific evidence of the relationship between the brain's motor cortex and its visual system, language systems, memory, attention, and cognitive processes. Subsidiary neuropathways branch off from existing neuropathways through movement, sensory experience, behavior, emotions, and thinking, facilitating "patterns of gene expression which enhance factors that support the encoding and transfer of data, synaptic structure, and the activity and plasticity of neurons, facilitating learning" [40]. Implications of the brain's capacity to integrate sensing, perception and motor activity are far-reaching because the brain does not differentiate action from thought, so that the power of imagination and self-awareness can become as potent in stimulating neurological change as is the physical act of doing.

## **5.3. Self-image and body image are grounded in perception and kinesthetic experience**

Self-image and body image, each having mental and neurophysiological components embedded in neurons, are virtually interchangeable within the neuroplastic brain [6]. "We act according to the image [self-perception] that we create of ourselves" [37]. "In order to change our mode of action, [once it becomes dysfunctional or fixed] we must change the image of ourselves that we carry within us" [37]. "When a sensory function becomes disturbed, the

body part affiliated with it stops sending normal sensations from it to the brain. The brain then alters its representation of that body part. People with distorted body image report feeling unbalanced, rootless, and ungrounded – all vestibular terms” [41]. When dysfunctional habits and patterns occur over a period of years, the structure of the brain changes to incorporate these habits and patterns, so the brain does not move on or “turn the page” [41].

“The representation or image of the self is one such pattern. The brains of individuals with ED have become committed to neuronal pathways that have temporarily obliterated more adaptive pathways [41]. It is not atypical for ED individuals who have achieved significant benchmarks of recovery (full weight restoration and normal hormonal function, significantly improved mental and emotional functioning, and increasingly healthy problem-solving and attitudes about food and eating) to remain painfully and indefinitely susceptible to an obsessive, distorted perception of the embodied self and body image. A recovering anorexic patient, obsessed with a distorted body- and self-image, described herself as remaining “trapped in this body image.” She was referring to her incapacity to take action in her life, to quit her job, separate from her husband, love herself, and move forward in her recovery, all due to her intolerable perception of her self.

Self-image is influenced by heritability, the socio-environment, as well as self-education [36]. Somatic education influences self-integration by providing a somatosensory, kinesthetically based, neurophysiological practice that educates and integrates the brain, creating an awareness of a sense of the inner body. By filling in gaps in body image, it redefines a more complete and accurate embodied perception of self. The repair and re-integration of perceptual-sensory dysfunction have been shown to take place through somatosensory movement. “Because the representation of the body is dominated more by external vision, and less by internal somatosensory information in healthy controls, somatosensory training increases the contribution of internal somatosensory information which could reduce or ameliorate the disturbance in the experience of the bodily self by helping to restore the balance between internal and external/visual information about the body [13]. Increasing interoceptive and/or proprioceptive awareness produces a less malleable and more accurate body perception and undistorted body representation.

“Mirror neurons reveal the fundamental integration within the brain of the perceptual and motor systems with limbic and somatic regulatory functions [5]. The “sensorimotor supremacy hypothesis” confirms that perceptual shifts draw on motor action; conscious and unconscious perception cannot be separated; and the correlations that give rise to conscious visual perception (i.e. body image distortion) can only be derived after the sensory inputs *and* their temporally trailing motor or premotor consequences” [42]. In addition, “it is likely that not only perception, but memory, and in particular sensorimotor/proprioceptive memory, shapes bodily experience in patients with AN. It has been discovered that “the relative proportion of positive to negative self-schemas (functional memory structures) available in memory may be the cognitive foundation of observed differences in global self-esteem, the affective component of the self-concept. Interventions promoting development of new positive self-schemas may be an important factor in identifying alternative sources of motivated behaviors and promoting ED recovery” [43].



## 6. Somatosensory interventions facilitate increased production of improved neuronal pathways and brain circuitry

The brain that drives the movement of thoughts and emotions also drives the movement of bodily feedback and sensation. Decades before the dawn of our current “era of the brain,” Moshe Feldenkrais theorized that various parts and functions of the brain, when activated, can be enlisted to facilitate change and enhance function in *other* parts of the brain, creating new and improved neuropathways to take the place of damaged, nonexistent, or dysfunctional ones. In his book, “The Brain's Way of Healing: Remarkable Discoveries and Recoveries from the Frontiers of Neuroplasticity” (first edition), Doidge describes the girl named Elizabeth who was born 37 years ago, missing a third of her cerebellum [41]. At birth, confined to a rigid and painful body devoid of movement, Elizabeth's infant brain was deprived of its most potent and prolific opportunity to develop neuronal pathways that would permit learning of any kind. Her restriction of movement was so severe during her first year of life that she could not control her eyeballs, and for a time was thought to be blind. By 13 months of age, when she began treatment with Feldenkrais, the only bodily movement she had mastered was to roll over on one side. Feldenkrais worked with Elizabeth as consistently as possible during the second and third years of her life, demanding a family lifestyle of frequent intercontinental travel. Following his sudden death during her third year of life, and throughout her childhood and teen years, Elizabeth worked intensively with Anat Baniel, one of Feldenkrais' protégés.

Gently and intentionally moving her body so as to stimulate her dormant brain to awaken to life, Feldenkrais gradually triggered functionality in her cerebellum, which in turn, triggered the creation of neuronal pathways in adjacent parts of her brain to compensate for those parts that were missing and damaged. After her first four 20-min lessons, Elizabeth's once dormant brain began to engage her body in its most primal form of reptilian creeping, marking the start of what would become the full sequential development of her brain, from back to front, from the motor cortex to the pre-frontal cortex, and would lead to her body's “rebirth,” and a full restoration of life quality.

Though several top pediatric neurologists offered a prognosis of profound retardation, incontinence, and institutionalization, where she would be restricted to bed and wheel chair, through on-going Feldenkrais Method treatment, Elizabeth's brain recovery would become complete, her life full and gratified. She has grown up to become a fully independent young woman today, with a rigorous education and two master's degrees, a successful and long-term marriage, and a business of her own. Feldenkrais correctly predicted that she would “dance at her wedding,” which my husband and I, as her parents, were grateful and proud to provide for her.

### 6.1. Clinical applications of somatosensory research in eating disorder treatment

#### 6.1.1. *Somatic education/the Feldenkrais Method of Somatic Education*©

Somatosensory movement techniques transmit information from the body's sensory receptors, via sensory nerves in the spinal cord, to sensory receptors in the motor cortex. “The part

of the brain that processes movement is the same part of the brain that promotes learning” [40]. Most of the neural circuitry from the motor cortex is “outbound,” influencing other parts of the brain involved in memory, attention, and spatial perception. Through the Feldenkrais Method of Somatic Education©, “the student learns to remain mindful and attentive to proprioceptive and exteroceptive sensations throughout the body while moving, and is taught to notice relationships and patterns of relationships between parts of the moving self” [23]. On the sensory level, communication is more direct with the unconscious, and therefore more effective and less distorted than at a verbal level [41]. Recognizing that sensory stimuli are closer to unconscious functioning than to conscious understanding, Feldenkrais’ work allows patients to consciously reconnect with their unconscious sensorimotor repertoire through sensory training that expands their movement repertoire. The method enhances the kinesthetic sense, which is, as our first and basic ability to perceive, deeply connected with our self-identity [41]. It has been said that “the Feldenkrais method offers entrance to the ground floor of our sense of self,” ... (taking) most adults back to infancy and mobilizing developmental processes at a fundamental level” [1]. In the end, what is recovered through somatic education in eating disorder recovery is the perception and connection to a sense of one’s own authenticity.

Within the Feldenkrais Method, the concept of two brains meeting within a mindful connection takes the form of human touch in the hands-on, Functional Integration©, technique. “Through touch, two persons, the toucher and the touched, can become a new ensemble where two bodies when connected...become a new entity. These hands sense, at the same time as they direct,” [44] a concept that currently resonates with the findings of Siegel and Schore vis-à-vis the dynamics of right brain to right brain resonance in psychotherapy. In Awareness through Movement© group classes, the student locates an awareness of self from within, and *inside* the teacher’s awareness of him” [44].

Unique among other somatic movement alternatives, such as trauma informed yoga, Nia, Tai Chi, etc., Feldenkrais’ Awareness through Movement © techniques actively and directly evoke the patient’s mindful attention to sensation, thought, and feeling in the context of movement, all components required to stimulate integrative neuroplastic brain change. In facilitating the ED patient’s self-awareness within mindful movement, the instructor of such somatic education techniques might inquire: “How does it feel to sustain contact with your body as you gently move and transition into the unknown?” “Is there a place inside of your body where you can go to feel fully safe...or unsafe?” “Can you sense your transition into the unknown as you move?” Filling the voids in body image and self-image through bodily movement with attention, somatosensory education fosters somatosensory reintegration and ultimately, the reintegration of the embodied self.

#### *6.1.2. The Feldenkrais Method and ED: research outcomes*

One of very few controlled studies of Feldenkrais’ method as an adjunctive treatment for ED concluded that the Feldenkrais Method as a body therapy is “particularly suited for those suffering from ED in fostering an improvement of body perception and a clarification of the body image, through which the satisfaction and acceptance of the body should improve” [36].

The German study of ED inpatients found an “increasing contentment with regard to problematic zones of their body (hips, thighs, buttocks) typical for ED, and showed that through (awareness-based) physical movement, compulsive behavior can be decreased and spontaneous behavior can be increased. Outcomes indicated the development of a “felt” sense of self, self-confidence, and a general process of maturation of the whole personality” [36]. In another study of ED women averaging 34 years of age, the Feldenkrais work resulted in their ability to consciously challenge dominant social discourse by engendering concrete changes in the way they perceived themselves. They reported being able to occasionally change their daily activities and various eating habits, thus revealing transfer of learning from the Feldenkrais classes to their daily lives” [45].

As a Guild Certified Feldenkrais Practitioner, as well as a psychotherapist specializing in the treatment of ED, I have enjoyed the privilege of enhancing recovery for my own ED patients through integrating the work of brain, mind and body, using adjunctive Feldenkrais practice. This work has now become readily accessible, both individually and through classes, worldwide. Instructive DVDs and short demonstrations of Feldenkrais movements are offered free through the Internet [46], accessible to home and professional office.

### 6.1.3. Case example: Functional Integration©

Case study. A young woman who struggled with bulimia, co-occurring addictions, body image distortion, and physical and verbal abuse by the men she dated, during a long and trusting therapy relationship with me, came into my office one day and sank deeply into the corner of the couch, emotionally frozen. Feeling massively agitated and depressed, clutching her jacket to her chest in an act of self-protection, her speech was incoherent and perseverative. Recognizing how incapable she was of accessing her self to engage in treatment this day, as a Guild Certified practitioner of the Feldenkrais Method of Somatic Education©, I spontaneously offered her the nonverbal somatic treatment option. She chose to engage with me in a Feldenkrais Functional Integration© lesson. Through this lesson I would engage her body in sequential movements uniquely tailored to the current requirements of her musculoskeletal, and nervous systems. I moved parts of her body gently and purposefully, with the intention of differentiating, and thereby reintegrating, neuromuscular and sensory elements within her nervous system.

In discussing her experience after the lesson, she reported that as she first lay down on the treatment table, she assumed that this would be “still another new-agey, bogus healing experience.” As the lesson began, she was aware of “thinking about all the things (she) needed to do once she left the session.” “But when I closed my eyes,” she said, “I was surprised to find myself focusing on changes that were taking place inside of me.” Having been so out of touch with the sensation of her body, she was astounded to discover herself thinking, “She’s touching my leg. Oh... I have a leg.” “She’s touching my arm. It’s weird that I have an arm and that it is attached to me.” The 40-minute lesson was transformational for this young woman. She left my office that day feeling whole, calmed, and at peace with herself. The jacket that had hidden her body previously, was now flung over her squared, and unconstrained shoulders as she strode out the door.

During the Functional Integration© lesson, the brain non-verbally integrates neurophysiological information offered by one nervous system, and accepted by another.

#### 6.1.4. Case example: Awareness through Movement©—the group experience

After a series of Awareness through Movement© group sessions, a compulsive runner reported becoming increasingly aware of her body in motion, of the bottoms of her feet as they struck the ground, as an example. She began to experiment with alternative options for initiating (and differentiating) her movements. Her experimentation evoked novel sensations, in propelling herself forward first from her toes, then her heels, her shoulders and hips. Through an accruing sense of self-awareness and honed self-determination, she ultimately found herself becoming newly capable of altering her compulsive running behavior, including the frequency of her runs, her daily mileage, and her time spent in this activity.

Eventually, in generalizing her empowered choice-making to other life spheres, she observed, “If I can make *these* kinds of decisions now, (about running) what’s to stop me from changing the way I make decisions within other parts of my life?” As she began to experience herself differently in her various life roles—as a marriage partner, parent, professional, and ED individual—her disordered behaviors began to diminish, losing their potency and purpose in her life. Some time after the group experience ended, she contacted me to report that she had recovered fully from her ED and had returned to graduate school to become a nurse, something she had wanted to do all her life.

This example of newly embodied self-sensing and self-determination demonstrates the relative immediacy of responsiveness to the Feldenkrais Method, as well as the potency of the partnership between body and brain, and its relevance to ED recovery. Part of the uniqueness of the Feldenkrais Method as an adjunct to psychotherapy is in the novelty of changing the endings of familiar internal narratives to become those that carry elements of change and limitless possibilities. In the case of ED, readiness for change is prerequisite to engaging in change.

## 6.2. Neuro-cognitive retraining interventions impact genetic trait characteristics and neural processing

AN research demonstrates that impairments in visuospatial ability, attention, memory and cognitive flexibility may be the result of genetically determined “trait” characteristics, rather than of a temporary state of starvation. Scientists believe that early in the course of ED, individuals may be compensating for disrupted processing during task performance by: (a) increasing the magnitude of response in neural circuits underlying attentional set-shifting and reversal learning in order to successfully complete cognitive flexibility tasks; (b) recruiting additional neural structures to offset inadequate activity in neural circuits underlying intentional set-shifting and reversal learning, or (c) both” [47]. “Cognitive retraining strategies that focus on specific processes that have relevance to particular psychiatric presentations (e.g., attention bias modification for anxiety disorders) have been shown to produce signifi-

cant decreases in psychiatric symptoms when compared to control interventions. Cognitive retraining interventions have been shown to help individuals accommodate other areas of dysfunction, even if underlying deficits do not change" [47].

## 7. Neurophysiological interventions in the treatment of co-occurring trauma

### 7.1. Understanding the trauma phenomenon

Trauma phenomena, which typically include diagnoses such as posttraumatic stress disorder (PTSD,) attention-deficit/hyperactivity disorder (ADHD), mood disorders, etc., typically co-occur with ED. It is believed that 30% of individuals with an ED have been sexually abused [48]. Childhood sexual abuse survivors have been found significantly more likely to become obese (42%) in young adulthood than nonabused individuals (28%) [49]. Interestingly, the obesity in this patient population has been shown to be relatively treatment-resistant [49]. Those who have experienced traumatic events may engage in ED behaviors and other forms of self-harm in order to manage feelings and residual consequences of these events. BN's binge/purge cycle has been connected to trauma as a means of self-protection, as the cycle reduces awareness of thoughts and emotions accompanying traumatic experiences, offering a cleansing escape from the experience and opportunity to refocus [48]. The effects of malnourishment on the ED brain, in some cases, will give rise to the symptoms of ADHD. In such instances, once the ED brain has returned to its normal functioning in recovery, the ADHD diagnosis may no longer apply.

All memory begins with sensory input [50]. Trauma is stored in somatic memory and expressed as changes in the biological stress response, creating undischarged energy in the nervous system [51]. "Traumatic memory stays 'stuck' in the brain's nether regions, in the nonverbal, unconscious, subcortical regions (amygdala, thalamus, hippocampus, hypothalamus, and brain stem), where they are not accessible to the frontal lobes, the understanding, thinking, and reasoning parts of the brain [51]. " "Because traumatic memories are encoded subcortically, rather than in conscious autobiographical memory, in seeking psychic change, "interpretation is limited in effectiveness with pathologies arising from the verbal phase related to explicit memories, with no effect on the preverbal phase where implicit memories are to be found" [52]. Trauma-informed yoga, as an example, is a neurophysiological intervention that naturally regulates the overwhelmed nervous system by bringing unconscious content from trauma-related neurological and muscular patterns into consciousness.

Intense emotions at the time of the trauma initiate long-term conditioned responses to reminders of the event, associated both with chronic alterations in the physiological stress response, accompanied by the amnesias and hyperemeses characteristic of PTSD [53]. The failure of declarative memory may lead to organization of the trauma on a somatosensory level (as visual images or physical sensations) that are relatively impervious to change" [52]. "The inability of people with PTSD to integrate traumatic experiences, and their ten-

dency instead, to contiguously relive the past, is mirrored physiologically and hormonally in the misinterpretation of innocuous stimuli as potential threats. In instances where continued physiological hyperarousal and altered stress hormone secretion affect the ongoing evaluation of sensory stimuli, it has been shown that bottom-up neurophysiological interventions more effectively address “the repetitive, unbidden, physical sensations, movement inhibitions, and somatosensory intrusions of unresolved trauma, than do top-down interventions” [54]. In such cases, a therapeutic model that effectively integrates both top-down (where the cranial brain sends messages to the body) and bottom-up interventions (embodied sensory receptors communicate with cranial based sensory receptors) best serves recovery [55].

The attuned therapist, in revisiting traumatic memories with the patient, seeks to find meaning in the experience (through differentiation,) and to provide a new, healthy narrative for the suffering individual (through integration.) In bringing implicit and explicit memories together, patients experience the attributes of integration – flexibility, adaptability, cohesion energy, and stability [4]. As the organization of the body changes physically in term of movement, posture, and arousal level, a different, more positive sense of self emerges [52].

## **7.2. Trauma-Informed Yoga**

Trauma-informed yoga provides an adjunctive, somatosensory treatment alternative by regulating the nervous system, bringing it from a disregulated state to a unified, centered state. Unprocessed traumatic memories stored in the brain become recycled when triggered, creating imbalanced patterns of nervous system activation. Teaching the use of breath, which evokes self-regulation, and facilitating close attention to present-moment awareness of self, yoga shifts sympathetic nervous system arousal to a balanced parasympathetic sense of calm and relaxation.

The trauma-informed yoga practitioner needs to conduct a full assessment of the patient's nervous system imbalances in order to provide postural movements that accommodate the individual's unique needs. Trauma-informed yoga has been shown to mitigate stress responses via both bottom-up (accessing the primitive brain and emotions) and top-down (psychological reappraisal) methods. Top-down cortically mediated techniques can be harnessed to observe and facilitate sensorimotor processing [56]. Controlled studies have demonstrated that certain “yoga practices decrease symptoms in PTSD, obsessive compulsive disorders, generalized anxiety disorder, panic disorder and anxiety after natural disasters...reducing the stress-induced allostatic load in the autonomic nervous system,” [57] It has also been reported that in yoga practitioners, brain volume is larger in areas that: contain a mental map of the body, direct attention, control vision, reduce stress, and define the concept of self [58]. Yoga has been shown to promote affect tolerance of physical and sensory experiences associated with fear and helplessness [34]. For ED patients suffering from co-occurring substance abuse or addictions, yoga-breathing practices may be useful in counteracting various types of urges brought on by environmental triggers that could result in relapse [34].

Psychosomatic expressions of bodily experiences are typically embedded in a broad variety of psychopathological and intersubjective phenomena [52]. “In seeking control of the traumatized mind-brain arousal system, the goal of trauma recovery is integrating what happened in the past with what is happening now, bringing ‘all parts of the brain online,’ in creating a sense of calm and safety in the present [53]. van de Kolk believes that trauma treatment allows the patient to (1) master the limbic brain (i.e., regulating the reptilian brain rhythms through breath control in yoga, meditation, or martial arts), (2) regulate heart rate variability and fluctuations through flexibility of breathing, and (3) engage in mindfulness, where, through activation of the medial prefrontal cortex, the patient develops an awareness of his own internal organization, potentially addressing it through “parts work,” that exists within the internal family systems (IFS) model of psychotherapy. In this context, patients confront and manage the dysfunctional parts of themselves (manifested in behaviors such as cutting, starving, bingeing and purging, substance abuse, morbid obesity, suicide attempts, etc.), which have evolved to help them “bear unbearable states, contain an unbearable internal world, and sustain them over the course of time” [50].

### **7.3. Eye movement desensitization and reprocessing (EMDR)**

Given the correlation between ED and the trauma of physical, sexual, and verbal abuse, eye movement desensitization and reprocessing (EMDR) has been shown to be a relevant, mindfulness practice for the treatment of posttraumatic stress disorder as a co-occurring diagnosis. As an integrative psychotherapy approach involving interpersonal, experiential and body-centered therapies, EMDR processes and resolves the experience, sensations and emotions around traumatic memory that are stored in the limbic brain. The method works by essentially using bilateral stimulation, and/or stimuli (visual, auditory or tactile) that occur in a rhythmic left-right pattern. Anchoring resources may include tactile stimulation, auditory tapping, or installing stabilizing imaginal resources through guided imagery [59].

### **7.4. Sensorimotor psychotherapy**

Sensorimotor psychotherapy is a mindful psychodynamic psychotherapy that includes the body as central in the therapeutic field of awareness. Promoting the same goals as psychotherapy, its practice blends theory and technique from cognitive and dynamic therapy with straightforward physical interventions, facilitating body awareness, sensation tracking, and empowerment. In identifying trauma reactions physically, it decreases the client's arousal level to “a window of tolerance,” allowing the body itself to lead the client into a necessary resolution and calming of the physical experience [52]. “Top-down, cortically mediated techniques are harnessed to observe and facilitate sensorimotor processing. Clinically, sensorimotor practitioners observe a mitigation of autonomic dysregulation as the client becomes more adept at self-observation, raising the question of whether mindfulness serves to engage the right orbital prefrontal cortex in regulating arousal” [52].

## 8. Other neurophysiological interventions that facilitate ED recovery

### 8.1. Neurofeedback/ EEG biofeedback training

Neurofeedback, or EEG biofeedback training, remediates the patient's self-regulation. Biofeedback is applied to the brain directly, as a noninvasive approach to operant conditioning of the electrical activity emanating from large groupings of cortical neurons, with the purpose of normalizing deregulated EEG activity. The technique represents an effective alternative for modifying the neurophysiological activity in the brain that contributes to specific cognitive processing, and emotional and behavioral dysregulation. Electrical signals can be used to present a variety of feedback stimuli that provide moment-to-moment information to an individual about the state of his or her neurophysiological functioning. Typically, sensors are placed on the scalp to measure activity, with measurements displayed using video displays or sound, which "feed back" information to the user, enabling that individual to discover how to change physiological activity to improve health and performance [60].

"Abnormalities in EEG activity are evident in people struggling with ED. These patterns of dysregulation are shown to normalize only partially with refeeding or weight gain" [60]. "According to a recent review of electroencephalography with ED, Ionacio Jauregui-Lobera notes "complementarity seems to exist between EEG and neuroimaging studies in terms of the study of overall functions, which result from an interaction among the different brain areas as well as the connections between them. ED might reflect some disturbances of a system of interconnecting pathways or circuits in the brain" [18]. These brain systems and networks are now being identified by techniques capable of refining existing operant conditioning-based therapeutic interventions for the entire spectrum of central nervous system (CNS)-mediated neuropsychiatric conditions to improve treatment outcomes [60].

It has been discovered that EEG functional abnormalities in the prefrontal, cingulate, and temporal regions respond differently to stimuli [18]. "After treatment, only those participants who had successfully normalized EEG activity in cortico-limbic/paralimbic brain regions could be considered in clinical remission for major depression. In these regions, significant correlations were found between the percentage of change of depressive symptoms and the percentage of reduction in high-beta activity [61]. These results suggest that the normalization of high-beta activity in cortico-limbic/paralimbic regions can be associated with a significant reduction of depressive symptoms" [61].

### 8.2. Deep transcranial magnetic stimulation (DTMS) heals co-occurring depression

Still another form of non-invasive technological brain intervention used successfully with ED patients includes deep transcranial magnetic stimulation, a high frequency repetitive transcranial magnetic stimulation applied to the left dorsolateral prefrontal cortex. This intervention sends low dose magnetic pulses to parts of the brain associated with treatment resistant



depression (TRD). One study suggests “4 weeks of daily DTMS over the left dorsolateral prefrontal cortex in a patient with severe TRD is associated with clinically meaningful improvements in both depressive and anxious symptoms, as well as in subjective quality of life” [62].

## 9. Conclusion

Mental disorders have been discovered to be disorders of disruptions in brain circuits. Abnormal behavior and cognition have come to be understood as “late and convergent outcomes of altered brain development” [63]. These concepts render antiquated, the notion that ED are merely chemical imbalances or social constructs. Practitioners and researchers stand on the precipice of a new age of ED diagnosis and treatment. Neuroimaging has begun to yield biomarkers, patterns that predict response to treatment or possibly reflect changes in physiology prior to changes in behavior or mood [63].

Through these advances, neuroscience has begun to shed light on *how* people make changes in psychotherapy. The role of the embodied self and somatosensory, bottom up education in the etiology, maintenance, healing and possible prevention of ED enlightens our understanding of how people learn and of what constitutes healing in treatment and recovery. Nowhere in the field of mental health are the concepts of the embedded self and embodied healing as significant as in the treatment of ED and body image disturbances.

Much of what we are learning about the neural basis of mental illness, however, is unfortunately not yet ready for the clinic, as clinicians as a whole are not adequately prepared through formal professional training to take on and integrate the full import of the role of the brain in ED onset, treatment, and recovery. To keep pace with neuroscience, ED clinicians require a broader knowledge of relevant brain plasticity studies and methodologies within our own field, and *within related fields*, in order to access and apply relevant principles of brain plasticity to front-line ED practice. By understanding more about the organ they treat, practitioners not only serve their ED patients, but also become instrumental in defining new directions for quantitative ED research.

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## Abbreviations

ED	Eating disorder, eating disorders, eating disordered
AN	Anorexia nervosa
BN	Bulimia nervosa
NIMH	National Institute of Mental Health
PET	Positron emission tomography
ARFID	Avoidant/restrictive food intake disorder
BED	Binge Eating Disorder
DBT	Dialectical behavior therapy
CBT	Cognitive behavioral therapy
ACT	Acceptance and Commitment therapy
MBCT	Mindfulness-based cognitive therapy
MRI	Magnetic resonance imaging
DVD	Digital video disc
PTSD	Posttraumatic stress disorder
ADHD	Attention-deficit/hyperactivity disorder
IFS	Internal family systems
EMDR	Eye movement desensitization and reprocessing
EEG	Electroencephalogram
CNS	Central Nervous System
DTMS	Deep transcranial magnetic stimulation
TRD	Treatment resistant depression

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