Emotional Brain Training:

The Neurobiology of Brain Retraining for Promotion of Adaptive Behaviors and State of Well-Being

Lindsey Fish de Peña, M.D., Clinical Research Fellow, Institute for Health Solutions; Laurel Mellin, M.A., R.D., Associate Clinical Professor of Family and Community Medicine and Pediatrics, School of Medicine, University of California, San Francisco, Director, The Institute for Health Solutions; Igor Mitrovic, M.D., Associate Adjunct Professor, Director of Professional School Education, Department of Physiology, School of Medicine, University of California, San Francisco and Scientific Director, The Institute for Health Solutions.

Under normal, everyday conditions without stress, the body is said to be in homeostasis. The term homeostasis was coined by physiologist Walter B. Cannon at the beginning of the 20th century. It is derived from the Greek *homeo*, meaning "same," and the Greek *stasis*, meaning "stable;" thus, homeostasis means "remaining stable by staying the same." Recently, Antonio Damasio (2003) has defined homeostasis as the state of high level well-being (not just the absence of stress).

In the face of distress, the normal response of a living organism is to employ all the resources to preserve itself. We refer to this generalized response as the *stress* response. This typically involves a number of systems and subsystems that include stress hormones, the sympathetic nervous system, cytokines, and a host of other defense mechanisms. These systems are designed to defend the organism and promote survival and are, in the short term, adaptive. Generally, they act by "ramping up activity" in various bodily systems (for example, an increase in

heart rate and constriction in blood vessels to elevate blood pressure) and maintaining this new level of activity in the system until the stressor has been eliminated, distress has passed, and homeostasis has been reestablished.

This new level of activity (as in the earlier blood pressure example) is maintained separately from the normal (*i.e.*, homeostatic) level of activity. Recognizing this as a normal adaptive response that shares characteristics with the homeostatic responses, Sterling and Eyer coined a new term — allostasis — to describe the phenomenon (Fisher, S. and J. Reason, Eds., 1988). Allostasis, a term similar to homeostasis, is derived from the Greek *allo*, which means "variable" and *stasis.* Allostasis describes the organism's ability to respond to distress by changing activity level and *maintaining* it at the new level for as long as necessary. In other words, it is the process of achieving stability (or viability), through physiological or behavioral change.

The response to distress which results in allostasis is then called the *allostatic response.* Allostatic response is necessary and it is adaptive in the short term (McEwen and Wingfield, 2003). However, in the long term allostatic response results in "wear and tear" on the body that results in damage. The concept of "allostatic load" was proposed as a "cumulative measure of physiological dysregulation over multiple systems" (McEwen, and Stellar, 1993), that is, the accumulated wear and tear that the body experiences due to repeated cycles of allostasis as well as the adaptations to the stress response (McEwen, 1998).

Allostatic load in body (*e.g.*, atherosclerosis) and mind (sensitization to the stress response) increase the frequency and duration of the stress response when the capacity to cope is overwhelmed by the combined load of internal and environmental stressors. Increased allostatic load has been associated with increased risk of disease (Adler, *et al*, 1993 and 1994).

Emotional Brain Training (EBT) is a program that teaches developmental skills that are hypothesized to decrease allostatic load by causing a decrease in the frequency and duration of the allostatic response and an increase in frequency and duration of homeostasis (*i.e.*, well-being). The program is known, in clinical settings, as The Solution Method™ for adults and, for childhood obesity prevention and treatment, as The SHAPEDOWN® Program.

The method was developed at the University of California, San Francisco, and has been used in clinical practice for nearly 30 years. The reports of those who have participated in this training have been remarkably positive. Many report that their lives have been transformed by the experience. Multiple scientific studies on the method are demonstrating lasting change in maladaptive behaviors including sustained weight loss, decreased depression, decreased blood pressure, and increased exercise (Mellin, *et al*, 1987 and 1997; Mellin and Krupp, 2006; Fernandes, Mitrovic, and Mellin, in process; Bates and Mellin, in preparation). This paper summarizes recent research on neuroplasticity and provides a conceptual framework for understanding the mechanism of the program's effectiveness.

The method was originally based on family systems theory and psychosocial development without hypothesis regarding the neurobiological mechanism for the program's effectiveness. It was first applied to the treatment of childhood and adolescent obesity, with the goal of improving treatment outcomes by integrating training in specific developmental skills into a comprehensive obesity treatment program. This innovation was created in response to the emerging research on the psychosocial contributors to obesity in the young, specifically, the role of dysfunctional family systems in the development and exacerbation of disease (Minuchin, *et al*, 1975), and the relationship between secure attachment (Bowlby, 1988 and Ainsworth, *et al*, 1974) and psychosocial development (Erikson, 1963 and 1982) and well-being. Obesity in children has been

shown to be associated with unresponsive parenting styles (Bruch and Touraine, 1940; Rhee, *et al*, 2006) and adverse childhood exposures (Felitti, *et al*, 1998). Intervening to improve family functioning has been shown to improve adiposity in children (Flodmark, *et al*, 1993). Therefore, training in the developmental skills that mirror secure attachment, responsive parenting styles, and healthy family functioning and enhanced development could impact positively a broad range of behavioral and health outcomes. The method was tested in its application to pediatric obesity then applied to adults and to a broad range of preventive and therapeutic applications.

More recently conducted research provides a conceptual framework of the neurobiological mechanism that is involved, and suggests why the method may be effective for selecting (or employing) adaptive responses in everyday life as well as in crises. The method addresses the range of sources of stress, as it includes decreasing lifestyle and medical contributors to stress as well as providing developmental tools to process current stress and desensitize the brain from the effects of past stress. The latter is of particular importance because stress originates not only from the external environment but also from the internal milieu, as the implicit learning from past experience is triggered by present stressors.

What appears important about this method is that by providing skills that enhance resilience, the stress response is more likely to be used only in a real crisis or acute stress. The brain may not amplify stress when there are no objective stressors with the risk of a set point of chronic stress. The possible impact of the implementation of a comprehensive intervention that addresses the whole range of factors that increase allostatic load and the sensitization of the brain to stress could be significant pertaining to individual and collective health status and health care expenditure, as estimated 80% of primary care office visits are stress-related (Kroenke and Mangelsdorff, 1989).

The foundational process of EBT is training individuals in the skills to identify their state as homeostatic or allostatic, to assess if it is maladaptive or appropriate for the current situation and, as necessary, change it until they accept their state or experience homeostasis (Mellin, 2008).

The primary tool of the method is called "Checking In." The process involves self-observation and a "decentered" view of one's thinking that has been associated with improved mood (Teasdale, J.D., *et al*, 2000). The individual then identifies his/her state of being, first as either in allostasis or homeostasis, followed by a further appraisal on a five-point scale from a full-blown allostatic (stress) response to homeostasis (well-being). In the next step, he/she decides whether to change or accept their state. If he/she accepts the state, that ends the process. If he/she decides to change their state, they use one of five intrapsychic tools in order to shift their state of being toward a state of balance. Each of the five tools corresponds to a different state of being on

Figure 1. Emotional Brain Training: The 5-Point System

Number	State	Secure Attachment (Attuned Parental Regulation)	EBT Tool (Self-Regulation)
1	Homeostasis (balance/reward)	Savoring Rewards	"The Sanctuary Tool"
2	Homeostasis (balance)	Checking Feelings & Needs	"The Feelings Check"
3	Allostasis (verge of a stress response)	Express Positive & Negative Feelings	"Emotional Housecleaning"
4	Allostasis (stress response)	Express Negative Feelings Appraise & Revise Expectations	"The Cycle Tool"
5	Allostasis (full blown stress response)	Reassurance & Guidance	"The Damage Control Tool"

Figure 1: Emotional Brain Training: The 5-Point System

the aforementioned five-point scale. After using the tool, the individual reappraises his/her state, and either accepts it or changes it, using the tool that corresponds to the state. The process is repeated until the individual accepts the state of being or appraises his/her state as homeostasis. Checking In is used ten times daily and the training in the basic skills to accomplish this involves four weekly sessions. Advanced training involves the completion of progressive courses to support decreasing allostatic load and retraining the brain to enhance psychosocial development, resilience, and well-being and, within the limits of genetics and circumstance, improvements in a broad range of stress-related maladaptive emotional, relational and behavioral symptoms. The six advanced courses are designed to be completed in 18 months. However, training continues until the individual experiences a new set point with less vulnerability to stress, more of the developmental rewards associated with homeostasis (Erikson, 1983; Mellin, 2008) and the diminishing of stress-related symptoms or what is referred to in EBT as a "Solution."

Each of the five tools in the system is hypothesized to provide the most effective process to prevent or terminate the allostatic response and promote homeostasis. Increasing the frequency and duration of homeostasis is hypothesized to promote psychosocial development (Erikson, 1982; Marcia, 1966). The skills are hypothesized to mirror authoritative parenting styles (Baumrind, 1991) for each of the five states and represent the internalized structures of authoritative parenting styles that contribute to secure attachment style (Frick-Horbury, 2001). Secure attachment style has been associated with self-regulation, the ability to maintain flexibly organized behavior in the face of high levels of stress (Siegel, 1999). In various states of stress, the application of responsive parenting varies with the critical variable being the parental attunement or limbic resonance, the continual awareness and responsiveness to the child's needs, regardless of the level of allostasis or homeostasis. Use of the tools may indicate changes in lifestyle, health care, or environment that will

decrease the frequency and duration of allostasis and increase the frequency and duration of homeostasis.

The limbic system is the clearinghouse of environmental and internal sources of stress, and when combined input overwhelms an individual's capacity to process it, the brain perceives stress and triggers an allostatic response. The frequency and duration of the allostatic response is influenced by allostatic load, with increases in frequency and duration associated with higher allostatic load.

At its basic level, EBT targets the neuronal circuitry involved in the stress response. The investigations of the last ten years have resulted in an enormous number of discoveries regarding how the brain functions and its capacity for plasticity. These recent discoveries have led to the identification of the likely functional neurobiologic mechanism behind EBT.

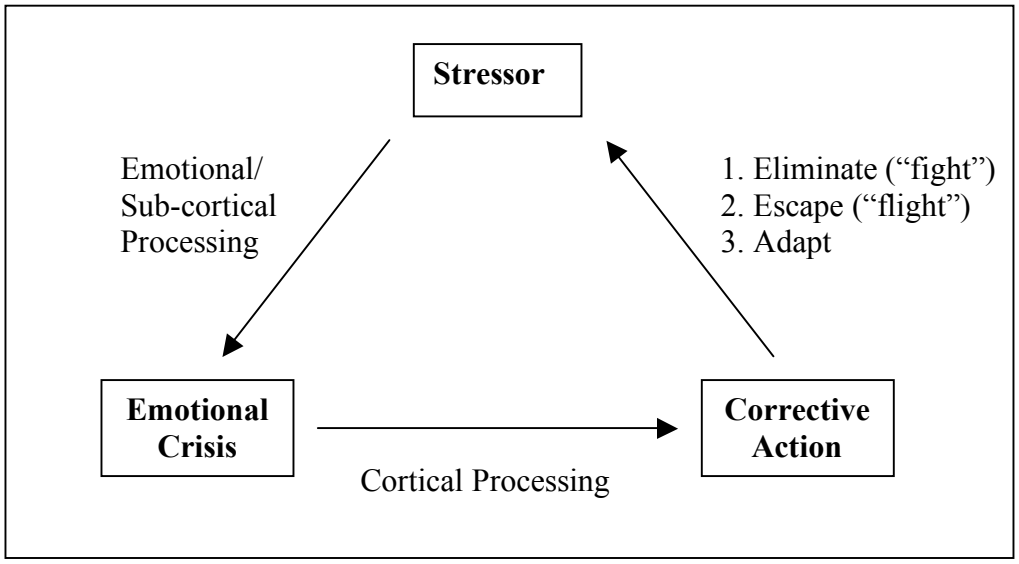

Figure 2: Stress Response Neuronal Circuitry

The non-anatomical neuronal circuitry of the stress response is illustrated in Figure 2. The initiation of the circuit begins with the stressor, which must be something threatening to existence. This induces a survival stress response. The introduction of a stressor is followed by a quick sub-cortical processing phase. This is a basic emotional processing using the emotions (physiological responses) of fear, disgust, or joy. If the stressor is threatening, the likely emotional processing will be based in fear. This will lead to an emotional crisis. The emotional crisis state will trigger a second phase, the cortical processing. This mode of processing combines the initial emotion with cortical thinking, thus creating a feeling. Often, in states of stress, the ability to think can be narrowed and may occur at only a slightly conscious level. This thought process is primarily influenced by previous experiences that are related to the current stressor and emotion. Ultimately, the feeling will lead to an action that will have an effect upon the stressor.

There are three options for corrective action: eliminate, escape, or adapt. In a confrontation with a life-threatening stressor, elimination is the "fight" response in an attempt to kill that which is threatening personal survival. Escape is the "flight" response, which is the attempt to remove oneself from the stressful situation. However, if neither elimination nor escape is possible, adaptation must occur.

Adaptation is learning a new method of survival, given the presence of a threatening stressor. The initial approach is the adoption of a new behavior in order to induce a change in the stressor; *i.e.*, to make it less threatening. If this is unsuccessful, a second approach at adaptation is adopted. This second approach is the adoption of a new behavior that attempts to decrease the fear and uneasiness induced by the emotional crisis caused by the stressor. Adaptation, by definition, can have both positive and negative effects both on the stressor and on the individual making the adaptive changes.

Following an initial encounter with a stressor, the neuronal circuit for this stress response is laid. Once laid, it is often repeatedly triggered. Any stressor similar to the initial stressor will often be followed by a similar emotional crisis, a similar cortical processing phase, and a similar corrective action. The more often this neuronal circuit is used, the stronger it becomes. It is a positive feedback cycle.

Given the recent explosion in the scientific data regarding neuroplasticity, it appears that EBT retrains the brain by decreasing the activation of maladaptive stress response neuronal circuits and developing the dominance of new, more positive, stress response neuronal circuits.

This conceptual framework focuses on the stress response, the allostatic response, and recovery to homeostasis. It appears that EBT targets each phase of the neuronal circuit of the stress response. The first phase of the stress response is the emotional/sub-cortical processing that leads to an emotional crisis. This emotional crisis cannot be changed, as it is an evolutionary response to threatening stressors. However, EBT, via the skill of "Checking In," brings the emotional crisis to the conscious level. Therefore, the person becomes aware of his/her state and can choose to accept it — decentering, which triggers an alleviation of stress — or to change it. Awareness of feelings has been associated with decreased stress (Lieberman, *et al*, 2006).

The second phase of the stress response is the cortical processing that leads to a corrective action. Awareness of feelings, emotional messages from the lower brain to the neocortex, reflects the implicit memory, the unconscious distillation of life experience. With awareness comes the opportunity for changing the implicit memory. The search for the "underlying expectation" is actually identifying the narrowed thinking process that occurs when the individual is experiencing this emotional crisis. The neuronal circuits aroused by the current stressor and those aroused by past stressors lead to awareness of a specific cortical thinking process that is linked to this emotional

crisis. This also leads to the identification of the corrective actions that have been used to address this and similar stressors previously. Using these skills, an individual is able to identify his/her personal neuronal circuit that is being activated by the current stressor.

If, upon conscious examination of the stress response neuronal circuit, an individual realizes that this circuit leads to a maladaptive or harmful behavior, EBT provides the skills to create and strengthen a new "reasonable expectation" and adaptive neuronal circuit for managing distress, thereby facilitating development and resilience. The stressor remains the same. The emotional processing remains the same. The emotional crisis remains the same. Therefore, the individual still experiences the same feelings during his/her "Checking In." However, EBT introduces a new cortical thought that strengthens the neuronal circuitry — both cortical and subcortical — that favors homeostasis, thus adjusting the cortical processing phase. This results in a new corrective action. Ultimately, the purpose is to eliminate the use of maladaptive behaviors and replace them with appropriate adaptive behaviors and train the brain to strengthen the neuronal circuits of fear, turning them to calm and building that essential emotional capacity (Siegel, 1999). If new adaptive behaviors are implemented, the method appears to decrease the fear induced by the stressor, and the individual is able to decrease the frequency and duration of allostasis and increase the frequency and duration of homeostasis. That state has been associated with adaptive behaviors and improved health and happiness.

EBT recognizes that a one-time cognitive awareness of a new "reasonable expectation" is insufficient to create a new dominant stress response neuronal circuit. The individual must repeat or "grind in" the expectation to strengthen the adaptive neuronal circuit for lasting change. Repetitive use of a body part causes growth in the brain. The more use a brain region receives, the larger space it occupies without detriment to surrounding regions or functions. This was discovered by Jenkins,

Merzenich, Ochs, Allard, and Guic-Robles in 1990, and reported in their article published in the Journal of Neurophysiology that year. **This is known as use-dependent cortical reorganization.**

Further research has shown that attention is crucial for use-dependent cortical reorganization (Rencanzone, Schreiner, and Merzenich, 1993). This indicates that having purpose, attention, and desire while doing EBT, especially while "grinding-in," will enhance the retraining of the brain. The purpose, attention, and desire that is the purpose of the training, that is, establishing a new set point of well-being may contribute to enhancement of brain retraining.

Paula Tallal of Rutgers University demonstrated that the human brain can also be retrained using her Fast ForWord program created with Merzenich. Using this program to improve dyslexia, 90% of children improved their reading skills, raising their assessment levels by 1.5-2 years following a training program of one hundred minutes per day, five days a week, for six to eight weeks (Merzenich, *et al*, 1996 and Tallal, *et al*, 1996). In fact, functional MRIs performed while the children read confirmed the change. Language areas of the brain which, prior to training showed a lack of activation, became active following this training, indicating that training can change the dominant neuronal circuit, thus changing the functionality of the brain (Temple, *et al*, 2003). Therefore, Emotional Brain Training, via the process of "grinding in," likely results in a cortical reorganization of the neuronal circuits and a strengthening of the synaptic connections within that neuronal circuit involved in processing the new "reasonable expectation." This repetition is the key to creating new dominant neuronal circuits.

In addition to a program of repetition to strengthen synaptic connections, EBT encourages the creation of enriched/nurturing environments and daily exercise, both of which have now been shown to increase the number of synaptic connections in the brain and to involve new neurons in neuronal circuits. These new and improved neuronal circuits increase learning, memory, and

behavioral performance in mice, regardless of age (Kempermann, Kuhn, and Gage, 1997). Additionally, there has been proof that new neurons are continually being made in the brains of humans (Eriksson, 1998).

Therefore, enriched environments generate denser synapses, more dendritic branches, and an increase in new neurons, all of which are important components in strengthening new dominant neuronal circuits. Further studies that attempted to isolate which component of the enriched environment had the greatest impact on neurogenesis found exercise (running on the running wheel for mice) to be the active factor (van Praag, *et al*, 1999). Therefore, regular daily exercise as recommended by EBT is a crucial element to creating a brain environment that is more supportive of growth and change.

The mechanism for increased neurogenesis in the setting of exercise appears to be the following. During the muscle contraction involved in exercise, the muscle releases IGF-1 (insulin-like growth factor 1). This chemical enters the blood and crosses the blood-brain barrier when it arrives at the brain, inducing the production of BDNF (brain-derived neurotrophic factor), a chemical which fuels many of the higher thought processes; the more BDNF in the brain, the more neurons, and the more dendritic branches and the more synaptic connections.

However, the effects of exercise on neurogenesis appear to have a volitional component, as discovered in studies in which mice were forced to exercise in order to survive. It appears that the stress of survival inhibits the positive neuronal effects of exercise and that neuronal cell growth appeared only in the animals that chose to exercise voluntarily. In addition, it appears that the new growth requires an enriched environment to survive (van Praag, *et al*, 1999). Therefore, exercise in the setting of a nurturing environment decreases stress and increases brain neuronal stimulation, resulting in new neuronal circuits with greater function and capacity. This data continues to support

the many components of Emotional Brain Training and why each component of the method is critically important for retraining the brain.

There is evidence that mental training too, can change the brain just as physical training of the body can change the brain. Mindfulness-based meditation in obsessive-compulsive disorder (OCD) patients has resulted in decreased harmful hyperactive brain activity and transformed lives due to fewer anxiety producing obsessions and more control of compulsions. Mindfulness-based meditation has also been shown to treat depression successfully and to decrease the recurrence rate of depression. This suggests that thoughts that trigger strong emotional responses as well as strong and deeply-seated emotional states can be altered, changing the activity of the brain, the emotional experience of the individual, and ultimately, the life of the individual.

Given this data, it is possible to train new emotional circuits. It has been noted that persons with high right prefrontal activity, as measured by electroencephalograms (EEGs), have more of a tendency towards a depressive emotional state whereas persons with high left prefrontal activity have more of a tendency towards a happy emotional state. There is a growing suggestion that this emotional state can be changed. In a study of the "happy geshe," a Buddhist monk known for his great compassion, his baseline EEG showed a slight left prefrontal cortex shift. However, when he meditated, his left prefrontal cortex had a left asymmetry of greater than 99.7%. Thus, his mental training and attention allowed for a shift in his emotional state (Begley, 2007).

In further investigative studies on multiple Buddhist monks who practice compassion meditation, there is evidence that suggests that repeated change of the present emotional state results in a longer lasting change in the emotional trait. During meditation, an EEG shows increased gamma wave activity, which continues between episodes of meditation. This continuation of the gamma wave state even while not meditating, provides the first piece of evidence that suggests that

mental training does not only affect the state of the brain, but also begins to create an enduring brain trait. This suggests that using the skills in Emotional Brain Training to change repetitively one's emotional state will leave an enduring emotional trait.

In conclusion, Emotional Brain Training is a unique synthesis of neurobiology and attachment theory into a system that the evidence suggests works to weaken maladaptive stress response neuronal circuits and strengthen new well-adaptive stress response neuronal circuits. The method has three key components: identifying the current maladaptive stress response neuronal circuit, creating a new well-adaptive stress response neuronal circuit, and increasing the new circuit's dominance via repetition in a nurturing environment. The evidence suggests that Emotional Brain Training may be an intervention that retrains the brain for sustained changes in health-related indices.

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Emotional Brain Training was previously referred to as Developmental Skills Training.

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