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SPECIAL ISSUE

Heart Rate in Trauma: Patterns Found in Somatic Experiencing® and Trauma Resolution

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Trauma is in the nervous system, not in the event.
—Peter Levine, 2006

The authors use physiological monitoring, especially heart rate variability, spectral analysis, and capnometry in measuring client psychophysiological states during Somatic Experiencing trauma resolution therapy. Somatic Experiencing constructs are described in the article. Heart rate variability and spectral analysis are explained briefly. Heart rate graphs are shown depicting different autonomic nervous system states (including the freeze response) during stages of Somatic Experiencing® trauma resolution and of the low frequency pattern, often called coherence, *that commonly accompanies resolution. Physiological monitoring is presented as a tool for research, for validating therapeutic constructs, and for feedback for client and therapist about their self-regulation states and progress.*

Physiological measures of stressed and traumatic states often are misunderstood or misinterpreted. There also is not complete agreement among researchers. However, there is growing evidence about findings in heart rate (HR), skin conductance (SC), peripheral temperature (ST), and capnometry (measuring carbon dioxide in exhalation), both in stressed/traumatized states and in their resolution. This article will provide a brief review of our recent findings, particularly about heart rate patterns in trauma and in the trauma resolution process of Somatic Experiencing. Graphs of heart rate variability (HRV) and the spectral analysis of HRV (a frequency analysis of heart rate changes) will be shown as examples of the differing states. A rationale will be implied for not just teaching relaxation skills but for (a) learning to attain or to recover a psychophysiological state of balance (called *resilience* in our SE work and *psychophysiological coherence* by the Institute of HeartMath) marked by a high amplitude of low-frequency heart waves, increased HRV, and healthy end-tidal carbon dioxide ($ETCO_2$), and (b) using a carefully titrated therapeutic process that evokes a more natural stimulus-response pattern of trauma resolution without retraumatizing individuals and that also results in the aforementioned state of balance and coherence.

Trauma and Trauma Release

Somatic Experiencing® (SE) is a trauma-resolution therapy developed by Peter Levine and taught internationally. It was first derived from ethological studies of how animals survive traumas by discharging the mobilized arousal and returning to normal function. Levine (2005) stated that trauma is stored more in the nervous system than in the event. Trauma may be stored as energy stuck in an incomplete fight or flight sympathetic nervous system (SNS) "accelerator" response (which also can be understood as a vagal withdrawal). It may also be in a behavioral freeze or "braking" shutdown, which is a parasympathetic nervous system (PNS) vagal response (Porges, 1995). Levine (1997) also indicated that there can be a thwarted fight or flight response accompanied by a sudden freeze, much like jamming both the accelerator and the brakes at the same time.

Below is Diane Heller's description of the trauma response and trauma symptoms. Understanding the physiological sequences related to threat response subsequently serves as the basis for SE work in trauma resolution.

Incompletion of fight/flight responses. Trauma symptoms occur when a person encounters a real or perceived threat and is unable to initiate or complete and discharge the threat arousal sequence in the brain and autonomic nervous system. Examples of incomplete orienting responses include orienting responses and self-protective actions including fight and flight in order to adequately discharge the normal fear and hyperarousal mobilized with the survival instincts.

Freeze and dissociation. When a person experiences a terrifying event, the threat response sequence is initiated. At these higher levels of fear and overarousal, the person often naturally disconnects from his or her body or dissociates from the experience if he or she reads it as life-threatening. This is a way to compassionately anesthetize against pain and extreme discomfort—and in practical terms, to prepare

for death. If this happens, the experience becomes frozen in the body and the person may feel shutdown, paralyzed with fear, or "not there" anymore in time or in body.

Time stops. During high arousal the brain stops recording the passage of time, so trauma survivors are caught in that worst moment, reliving it over and over again. Bessel van der Kolk (2007) quoted Fritz Perls as saying, "In the stream of life, it's just one damn thing after another." Noting that in trauma, time stops, van der Kolk said, "For trauma survivors it's the same damn thing over and over again."

Movement through time and weaving a "then and now" focus toward being in the present. In therapy later we need to help the client move through time again so he or she is no longer trapped in arousal-encapsulated experiences from the past that effectively prevent experiencing the here and now and the ongoing passage of time related to that event. "And what happens next?" "And as you recall that, what happens in your body now?" "As you notice that relief in your body, how are you experiencing the environment now around you?".

Resourcing and down-regulating. One of our goals is to reduce arousal and increase "resources" (defined as any positive memory, person, place, action, or personal capacity that creates a soothing feeling in your body" [Heller, 2001, p. 63]), a down-regulating of anxiety and an awareness of a felt sense through focus on physical sensation, then moving clients through time in a way so that they can keep their awareness intact and not disconnect from challenging experiences. SE is designed to help clients move through overwhelming life experiences without becoming overwhelmed in the process.

Discharge of arousal to reduce symptoms. In SE we believe that when overarousal in the ANS crosses a certain threshold, the body loses its capacity to discharge arousal and the excess energy becomes bound into symptoms. In therapy later we need to excavate the original fear from the symptom and direct it toward the original threat with enough support to keep the arousal level manageable for clients. This allows them to access the necessary self-protective actions and complete them. In this way, discharge can happen and the symptoms lose their "job" of binding excess energy.

What happened is irrelevant, as trauma specialist, psychiatrist Bessel van der Kolk (2007) said. We use content to find residual overarousal and discharge it to alleviate symptoms. What is important is reregulating the ANS and brain after trauma has dysregulated the natural physiological rhythms in the body such as sleep, breathing, appetite, sexuality, temperature, and social engagement—anything that the ANS influences.

Gentle demand on regulatory function to reestablish capacity through corrective experience. How can we work with dysregulation? We need to understand what healthy regulation is and that people have the hardwiring for health. One possibility is to make an appropriate demand on a regulatory system in the body to evoke and activate it with appropriate support so that it can reset, so to speak. Overarousal from stuck, unfinished threat responses disrupts normal regulatory functions. Discharging the overarousal heals many problems in and of itself. Sometimes more is needed and we can use a corrective experience clinically setting up a situation that helps the healthy regulatory function surface and not be inhibited due to a previously threat-related fear.

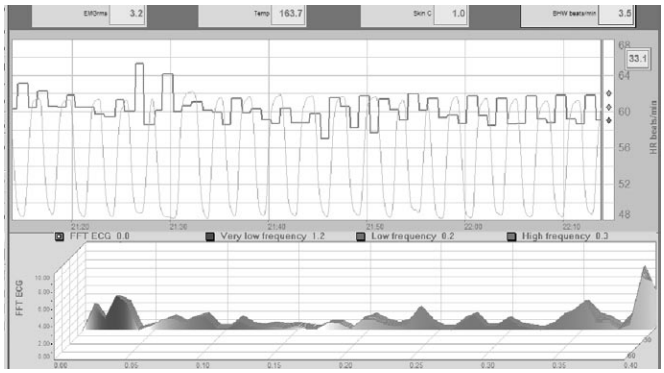

Figure 1. Example of freeze response: high frequency (HF) dominance (in bottom graph) with low amplitude, low heart rate (HR) and low heart rate variability. Also low skin conductance. Variations on this freeze can include high amplitude HF. The top graph shows 60 seconds of HR with $ETCO_2$ as the faint gray line with peaks showing CO_2 at end of each breath, 20 in this case, at an average of 32 torr, where the straight line is 35 torr, the minimum recommended.

For example, if a client was a child of hostile parents and adapted by becoming extremely self-reliant and avoiding people, we may begin to work to bring safer people into the client's awareness so that he or she can eventually open up to the risk of allowing others to be a part of the client's support system again. At first this may feel like a great risk to the avoidant client. The adaptation may be so strong for clients at first, they may not even imagine allowing others in without the intervention of the skilled therapist. Eventually, as we gently put a demand on the client's healthy attachment system and with enough successful connection, this can be a great relief.

Heart Rate in Stress and Trauma

One of the first stress responses in orienting to a sudden, potentially threatening stimulus sight or sound is the immediate slowing of the HR, which is PNS activity via the vagus nerve. This may be followed by a systemic shut down (also called a *behavioral freeze*), including a drastic drop in HR via the dorsal branch of the vagus nerve (Porges, 1995), if the threat is perceived as overwhelming, if escape or fighting

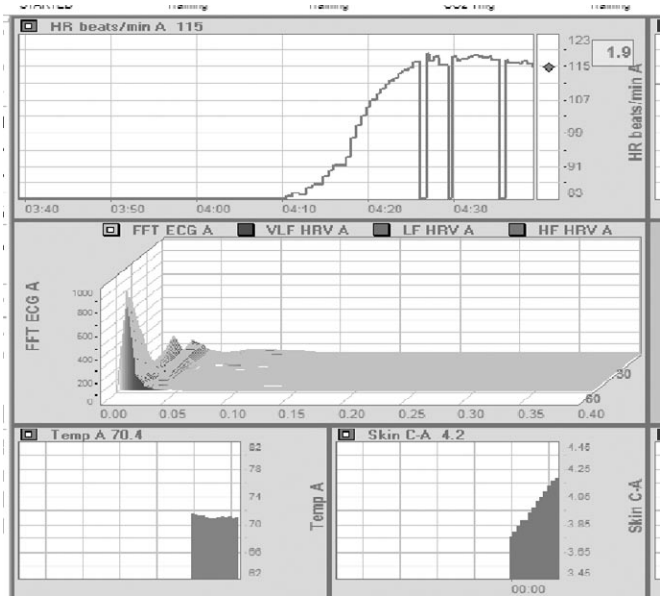

Figure 2. Example of beginning of global high activation. Top graph shows 30 beat increase in heart rate in 15 seconds followed by some missed beats. Second graph shows very low frequency heart waves amplitude increase from 150 at back of graph to 800 15 seconds later. Bottom graphs show cold hand temperature of 70.4ºF on left, and on right escalating skin conductance over 15 seconds.

is not an option, or if the threat is generated internally. If the threat is perceived as potentially manageable, the physiological response will include either a sympathetic nervous system (SNS) activation with increased HR in a mobilization for fight or flight or the higher-level engagement of social behaviors (or "social engagement"—which Stephen Porges calls an emergent biological state that is phylogenetically a higher form of stress response) to ameliorate or resolve the situation (Porges, 2007). Prolonged and/or repeatedly unresolved or uncompleted stress responses may result in significantly elevated (i.e., SNS-mediated) or lowered (i.e., PNS-mediated) resting HR (Levine, 1997) and hypervigilant or dissociated behavior.

HRV, Spectral Analysis, and Capnometry in Stress and Trauma

Although biofeedback measures of SNS and PNS have been well used and researched, there are two relatively new measures that are uniquely useful in documenting and tracking these changes in psychophysiological states and stages. One measure is capnometry, the measurement of $ETCO_2$, which documents the extent to which a person is either breathing chemically efficiently or inefficiently, whether in a stressful moment or chronically. The other is HR monitoring, which can be done with a photoplethysmograph (PPG) or electrocardiogram (ECG). HR monitoring has advanced considerably beyond just giving an average pulse rate. Now computerized HR monitoring can show not only average rate, but variability in rate on a beat-to-beat basis. The plotting of these interbeat intervals or beat-to-beat rates is called HRV, which is a time-domain analysis. An additional measure is the power density analysis or power spectral analysis (PSA), a frequency-domain analysis of HR data. In this analysis, the computer takes the HR data and breaks them down into their component frequencies, which could be called "heart waves," just as the component frequencies of EEG are called *brainwaves*. In other words, each frequency range comprises changes in HR of a similar time frequency. For example, low-frequency heart waves are HR changes that cycle at a frequency between .04 and .15 Hz, or cycles per second.

In biofeedback monitoring of individuals describing or reliving trauma experiences, I (Whitehouse) began noticing physiological correlates of the same states and stages that Levine identified in his works. The first I noticed was a bimodal SNS and PNS pattern in the PSA with a client who, when asked why she came in to see me, immediately began reexperiencing the panic in a recent car accident she couldn't escape. I then went to Diane Poole Heller, PhD, to share these findings of the physiology matching a thwarted fight/flight response that suddenly became a freeze response, with high activation in both SNS and PNS at the same time. Heller invited me to give a demonstration in an SE training by monitoring a therapist who as client was processing a trauma with Heller's help. In the session all the other therapists being trained could see the physiology matching the progression through trauma release. Then Levine too began having me monitor sessions for advanced SE training. In my own practice I frequently use SE strategies and am

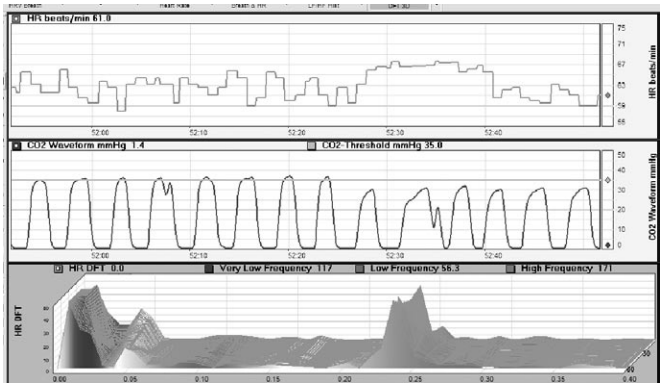

Figure 3. Example of exhaustion and thwarted stress response. Top graph shows 60 seconds of heart rate (HR) with low heart rate variability and some elevation around a stress. Second graph shows breathing rate of 14 breaths in that minute of data. Note drop in $ETCO_2$ from 36 torr to 30 torr starting with the increased HR, and as she begins to feel futile. Bottom graph shows bimodal spectral peaks of very low frequencies and high frequencies, which suggest "accelerator" and 'brakes" both being on at the same time, in this case at low amplitudes, though it can also be at high amplitudes.

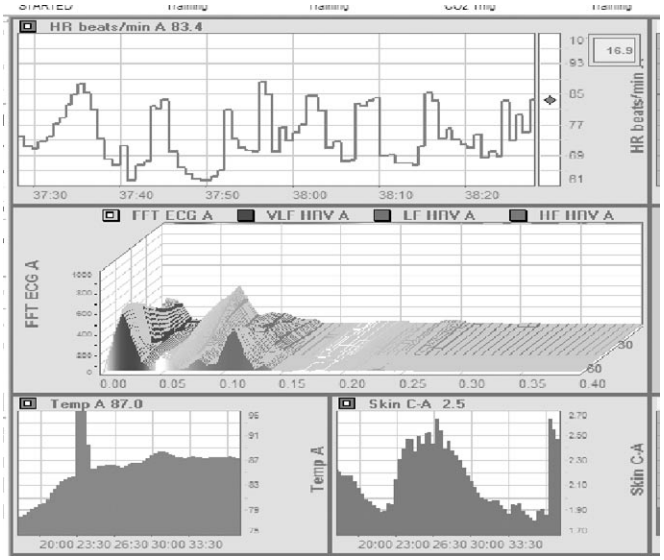

Figure 4. Renegotiating. Top graph shows heart rate varying, having come down from higher activation. Second graph shows spectral patterns of both very low frequency and low frequency, which I find frequently is reported as excitement rather than fear. Bottom left graph shows rise in left hand temp from low 70s to 87ºF in the last 20 minutes. The right hand graph shows the ups and downs of skin conductance.

nearly always monitoring and documenting at least HR. As appropriate, I provide self-regulation training using the monitoring as biofeedback. Below are descriptions and examples of the HRV and PSA patterns typically found in different trauma reactions, all coming from SE sessions and in these cases shown in graphs from the Capno Trainer® (Better Physiology Ltd., Boulder, CO).

ABCs of ANS Regulation

For simplicity in communicating ANS patterns to clients, I refer to **A** as SNS **A**ctivation, **B** as SNS-PNS **B**alance, and **C** as PNS activation, which is **C**alming and restorative.

A: SNS activity measures in biofeedback are elevations in skin conductance, lowered peripheral temperature, low HRV, predominance and escalation of very low frequency (VLF) heart waves of .0033–.04 Hz (cycles occurring in 25 seconds–5.6 minutes), faster breathing, and frequently also lowered $ETCO_2$. VLF waves are found to be more prevalent than the other frequencies about 90% of the time and are especially dominant with ruminative or worrisome thinking (Gevirtz, 2000). Elevations of the VLF range are reflective of a level of vigilance and when highly activated can become the powerful fight/flight response. Physician Will Evans (2003) refers to this SNS activity as the vigilant or life-protecting influence.

C: PNS activity that is calming (Evans calls the PNS the nurturing or life-sustaining system) is indicated by increased activity in high frequency (HF) heart waves of .15–.4 Hz (in cycles lasting 2.5–6.7 seconds), and if breathing is rhythmic there also will be greater HRV (which is then called *respiratory sinus arrhythmia*, because the HR will increase on the inhale and decrease on the exhale). Here a person's $ETCO_2$ may be more likely to be at or above the minimum healthy standard of 35 torr (4,666.2 pascals). (A torr is a unit of atmospheric pressure used to quantify the amount of CO_2 in the airstream or the bloodstream. One torr is equivalent to 1 mm of mercury or 133.32 pascals.) Surprisingly, however, we find that many persons breathe too deeply when trying to calm and actually drop their $ETCO_2$ below desired levels of 35–45 torr (Litchfield, 2003). Hands and feet also may be warmer when there is PNS calming and healthy breathing.

Dorsal vagal PNS activation in the extreme is the shutdown or freeze response and is accompanied by extreme drops in HR (Porges, 1995) and by low HRV and peripheral cooling or a flooding warmth that is uncomfortable.

B: SNS-PNS balance in heart frequencies is represented by the dominance of low frequency (LF) waves (.04–.15 Hz). SNS-PNS balance may be accompanied by high HRV, but that is not always so. The Institute for HeartMath slightly extends this range (.04–.26 Hz) to include some HF waves and calls this *heart rhythm coherence* (McCraty, Atkinson, Tomasino, & Bradley, 2006).

In the middle of the LF is the heart's resonant frequency, around .1 Hz. Every system has a resonant frequency, which by definition is that system's strongest, most stable frequency. When that frequency range appears in the heart waves, it becomes an organizing principle for other systems,

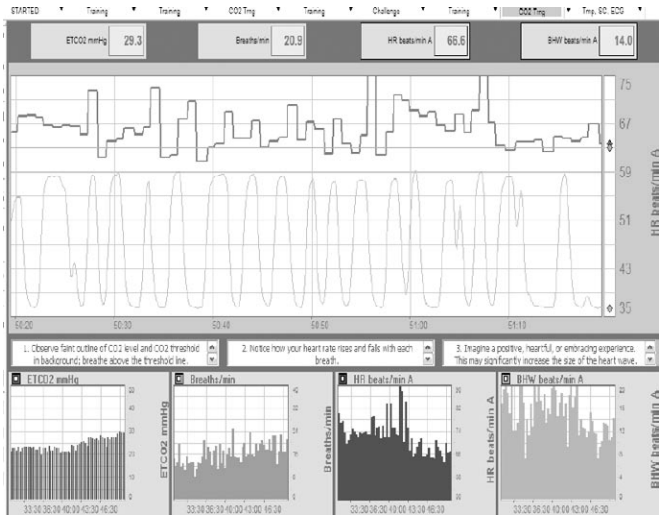

Figure 5. $ETCO_2$ levels for the same client are returning toward the desired level. Top graph gray lines show 18 breaths that minute and $ETCO_2$ levels are at 28–30, while the minimum healthy level is 35 torr, at or above the straight line. The bottom left graph shows her beginning $ETCO_2$ levels of 22 and their beginning return in her renegotiated response to nearly dying in scuba diving when her tank failed. In Figure. 4 note how rapidly her hands warmed as she came out of the freeze response.

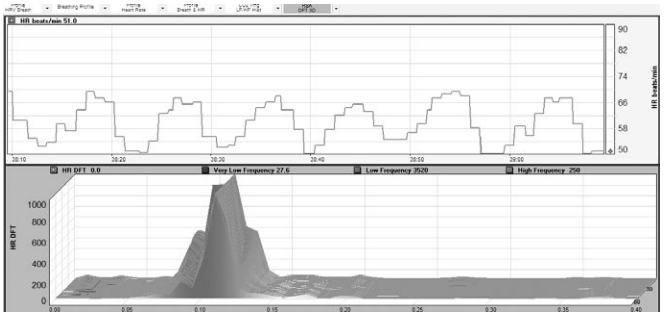

Figure 6. Resilience or coherence with resonance. This is an example of what one can train with breath and/or positive emotions but what we usually see also when trauma or stress has been successfully resolved/renegotiated. Top graph shows heart rate variability of almost 20. Bottom graph shows high amplitude low frequency waves peaking at the resonant frequency of 0.1 Hz.

and they begin to move toward homeostasis. Blood pressure tends to normalize as does hand temperature, SC, breathing, and other activities. As HeartMath research demonstrates, when heart rate becomes coherent (with a resonant frequency showing up in that range), the brain then synchronizes with the heart and performs better on cognitive tasks, the immune system boosts, we are more emotionally open yet less affected by negativity, and intuition may open (McCraty et al., 2006). Other research shows positive changes in health and emotional conditions (Lehrer & Vaschillo, 2003; McCraty et al., 2006).

Although one can achieve the LF heart waves by accessing positive emotions or by slow deep breathing, we very frequently find that slow deep breathing drops one's $ETCO_2$ to a level that will trigger anxiety or lethargy. Therefore, the ideal is to make sure the breathing chemistry is healthy in any state (i.e., above 35 torr [Litchfield, 2006]).

In SE work we find that once a traumatized person's threat response is successfully renegotiated and the constricted energy released, the LF pattern spontaneously appears with a high resonant frequency peak and the person socially engages others with smiles and reconnection and/or has an experience of expansion indicative of what could be called moving toward spiritual maturity. There is also peripheral warming and normalizing of $ETCO_2$. Such a state of recovered balance in SE terms is called *resilience*, which is defined by Heller (2001) as "the ability to overcome great obstacles and bounce back" (p. 81) and by the American Psychological Association (APA, 2004, p.2) as "the process of adapting well in the face of adversity, trauma, threats, or even significant levels of stress." This LF pattern with an resonant frequency peak also may appear at numerous other times when a person is feeling "resourced," an internal sense of integrity and integration.

We believe that attaining such a resourced, integrated state is possible more often, whether attained by skill-based biofeedback training, by use of special techniques such as HeartMath's emotional restructuring, meditation, certain focused breathing exercises (though caution should be exercised to make sure someone is not dropping their CO_2), or by the skillful use of such somatic-based therapies as SE.

Relationship Between Core SE Concepts and HR Variability and Spectral Analysis

Below are descriptions and examples of the HRV and PSA patterns typically found in different trauma reactions; each of these comes from an SE session.

We are suggesting that HR analysis (HRV and spectral analysis) is a viable and valuable way of tracking stressful/traumatic states and their resolution. In SE terms we are hypothesizing that a state of:

1. *Shutdown or freeze* is evidenced primarily with overall low amplitudes in spectral power, low HR, low HRV, and a relative HF dominance compared to other frequencies. This may represent a state of dissociation. (See example in Figure 1.)
2. *Global high activation* is of high-amplitude spectral power, with a predominance of VLF and low HRV if there is panic or rage, or a high-amplitude HF and low HRV, if there is high activation freeze. (See Figure 2.)
3. *Thwarted*, that is, uncompleted fight/flight (mobilized SNS states) and freeze (PNS immobilization states) can occur simultaneously and be accompanied by bimodal peaks in VLF and HF. (See Figure 3.)
4. *Renegotiating* incomplete defensive actions thwarted in the trauma is accompanied by the restoration of active defensive responses and discharge of these "stored energies," effecting a release or transformation of the trauma. During this restoration process, shifts occur in HR, HRV, and spectral frequencies that match the mental-emotional-spiritual-physiological processes and state changes. (See Figures 4 and 5.)
5. *Resilience* is a resident property of resonance. It can be accessed in the completion of movement from freeze through (active) fight/flight, and/or it can be experienced as a result of such a successful renegotiation. We believe it is both a state of SNS and PNS balance, with high-amplitude LF, especially at the cardiac resonant frequency (around .1 Hz), usually but not always accompanied by high HRV and accompanied by positive emotions and social engagement behavior. (See Figure 6). Another pattern appearing on occasion is of harmonic spectral peaks at all frequencies accompanied by low HRV, a pattern which is now called "emotional quiescence" at HeartMath (McCraty et al., 2006).

Conclusion

In summary, the authors have found that monitoring heart rate, HRV, respiration, and other autonomic measures is a useful adjunct in stress and trauma resolution therapy. It has provided physiological data that validates constructs used in the SE approach. In this trauma resolution method, patients/clients usually are not taught specific relaxation techniques but are asked to experience various resource states and memories and to notice the felt sense or physiological shifts occurring with those desired states. While processing traumas, the therapist monitors the client's arousal states (from shutdown to high activation) and coaches the client through a renegotiated response to the threat/trauma so that the nervous system can release its tensions in a gently unfolding way so as not to deepen the trauma. The trauma typically is correlated with high arousal levels in one or more heart wave patterns, whether at high or low energy levels. When the trauma is released, there is typically a strong rise in LF waves accompanied by positive emotions, a greater sense of being present, and more contact with oneself and others, i.e., what is called social engagement. We find that clients report feeling significantly more resourced and validated when shown examples or summaries of their physiological data and the shifts in ANS activity. This is experienced as confirming the successful processing of their traumas. Repeatedly, clients say that seeing the physiological data made the changes they made even more "real" or powerful.

This new approach to monitoring and giving summary feedback (even if not concurrent feedback) during a session is promising for (a) documenting beginning and ending physiological states within and between sessions, (b) providing new research in identifying differing states that accompany stages in trauma release, (c) validating whether or not theoretical constructs in various therapies have the expected physiology and effects, (d) providing reinforcing feedback to both client and therapist about state changes and progress, and (e) with our new dual-monitoring software, letting us monitor two clients at the same time, or client and therapist, to see when there are patterns of resonance, entrainment, matching, and pacing, as well as the therapist's own physiological baseline and changes, thus helping the therapist in self-regulation.

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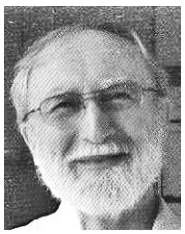

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