Life, Entropy, Information, Emotions, and Trauma

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ABSTRACT

In this article, I will introduce concepts from biology, chemistry, thermodynamics, and information theory to derive a unified theory on how life is sustained, based on the reduction of entropy (disorder) within living organisms. I will use information theoretic neuroscience to show how the concept of entropy can be applied to psychology, and to suggest that emotions represent entropy within the unitary psychosomatic structure. I will discuss the relationship between emotions and feelings, and the role that each plays within the psyche. Based on these roles, I will present a technique to discharge excess emotional energy. I will also introduce a simplified theory of object relations and self-psychology based on the reduction of entropy, and a technique to speed up the treatment of relational trauma. On that basis, I will discuss memory reconsolidation theory, and show how traumatic memories can be revised during the reconsolidation phase. Two techniques, based on memory reconsolidation theory and information theoretic neuroscience, will then be introduced that can be highly effective in treating shock trauma and erasing the emotional content of traumatic memories.

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If the soma feeds on negative entropy, so should the psyche.

The Beginning of Life

Earth was formed about 4.5 billion years ago, and life began here about a billion years later. The oldest fossilized microbes provide evidence that life on Earth might have appeared 3.8 billion years ago. But how did life begin on our planet? This is an old question that many have attempted to answer, yet no fully satisfactory response has yet been offered.

In 1924, the Soviet chemist Alexander Oparin (1965) and, independently in 1929, the British biologist John Haldane hypothesized that Earth's early atmosphere was very reducing – in other words, limited in oxygen (Tirard, 2017). Under these conditions, in the primordial soup of oceans filled with organic molecules and powered by the sun, Oparin and Haldane both hypothesized that organic molecules could have gone through a series of reactions resulting in the formation of more complex organic molecules and compounds. Oparin (1965) further hypothesized that early protocells formed in this manner might have been coacervates (Figure 1). In water, organic materials do not disperse uniformly, but instead lump together and may form droplets (as when oil is added to water). If these droplets form in an aqueous environment as colloids (a homogeneous substance consisting of large molecules) tightly surrounded by a semipermeable boundary of water containing complex organic compounds and molecules, they are then known as coacervates.

Coacervates have the interesting property in that they allow absorption of simpler organic compounds from their environment – a process that Oparin believed was similar to metabolism (Oparin, 1965). Oparin found that, under certain conditions, coacervates can be stabilized in water for weeks if they can me-

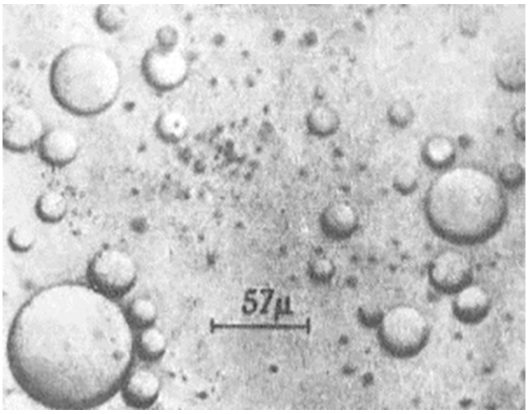

Figure 1. *Coacervates* (Oparin, 1965)

tabolize energy. To accomplish this, Oparin added enzymes and glucose to the water. Coacervates absorbed the enzymes and glucose, and the enzymes caused them to combine the glucose with carbohydrates already present in the coacervate. This caused the coacervates to grow in size. Waste products from the reaction with glucose were expelled. Once the coacervates became sufficiently large, they began to spontaneously break up into smaller coacervates (Oparin, 1965, p. 250-252), and the process continued. It is noteworthy that by absorbing matter and energy, a structure as simple as a coacervate can maintain some semblance of order within its boundary. Interested readers must note that coacervates are not cells, and lack the conditions of life. However, coacervates have boundaries, exchange energy with their environments, and can grow in size (Oparin, 1965, p. 250-252). They can thus be considered simple systems capable of maintaining a certain degree of order within their boundaries. The Oparin-Haldane hypothesis has recently received renewed interest, and coacervation theory, and coacervates as early protocells, are topics of active research (Lazcano, 2015).

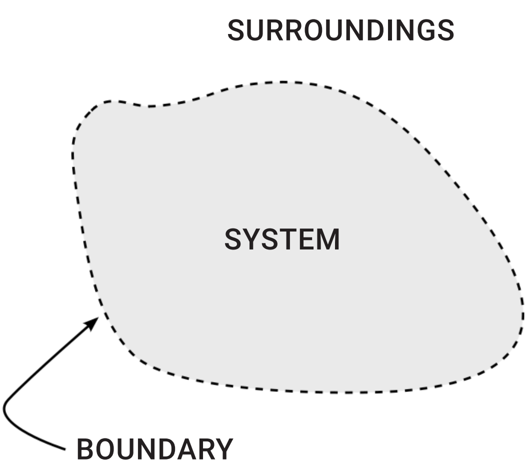

Figure 2. *Basic System Model*

Systems

A system can be viewed as a group of interacting, interrelated, and interdependent elements, as well as bounded processes. Systems transform inputs that are consumed into outputs that are produced. A system is characterized by its boundary, which separates it from its environment or surroundings. This boundary may be real or notional, but it defines a finite volume within which the system operates, and exchanges energy and/or matter with its surroundings. Systems are also characterized by their internal laws of function. A general system model is shown in Figure 2. Systems can be open or closed.

The dynamical system concept describes the behavior of the system as dependent on the time and position of the system in space. Complexity in a system indicates how relationships between parts give rise to new behaviors, and how the system interacts and forms new relationships with its environment. Complex systems are open and dynamic, and tend to be self-organizing. Self-organization is the process by which the system may form a structure or pattern in its behavior without imposition by an external entity or element. This structure or pattern forms from the interaction of elements that make up the system, and results in self-organization.

Living organisms can be considered as dynamic systems in the most general sense of the term, and are considered subsets of all systems. By definition, living systems are complex and self-organizing, with the special characteristics of life, and interact with their environments (open). Interaction with the environment generally takes place by means of material-energy exchanges that are governed by the laws of thermodynamics, which I will discuss next. Living systems can be as simple as a single cell, or as complex as human beings.

Life and Entropy

Readers may skip the mathematical concepts and formulas; they are included in this article for rigor, accuracy, and thoroughness, but they are not necessary to fully understand this work. Readers may simply focus on how these concepts are interpreted.

Thermodynamics is a branch of physics that explores the relationship between heat and other forms of energy. Most of us are familiar with the first law of thermodynamics, which essentially states that energy cannot be created or destroyed (the law of energy conservation). Of interest here is the second law of thermodynamics, which states that during energy exchanges between systems (or transfer of energy within a system), more and more energy is wasted, and systems move more and more toward disorder (greater entropy). Entropy, "S" in thermodynamics, is defined as the ratio of energy supplied over the absolute temperature at which it is supplied (Van Ness, 1969). That is, $S = Q / T$. Q is the energy measured in joules, and T is the absolute temperature measured in degrees Kelvin. For example, suppose that 5,000 joules of energy are transferred from a hot reservoir at 500 °K to a cold reservoir at 200 °K, assuming no change in temperature and no loss of energy due to work. The change in entropy is $\Delta S_{\text{total}} = S_h + S_l = -5{,}000 / 500 + 5{,}000 / 200 = 15$. The '$-$' sign indicates the negative transfer of energy from the hot reservoir, and Δ denotes difference. The entropy of the system of hot and cold reservoirs increases as energy is transferred from one reservoir to another. The second law of thermodynamics indicates that the change in entropy is always positive. Furthermore, the increase in entropy results in a certain amount of energy not being available for work after the transfer. The wasted energy is $\Delta S \times T_l$, which in the above example is $15 \times 200 = 3{,}000$ joules. As mentioned, an increase in entropy is related to increased disorder. This can be seen by considering a melting ice cube. Energy transferred to the ice results in melting, and transforms ice into water. It is clear that molecules in water move more randomly (with greater disorder) than do molecules in ice, and are thus more disordered. This process is depicted in Figure 3.

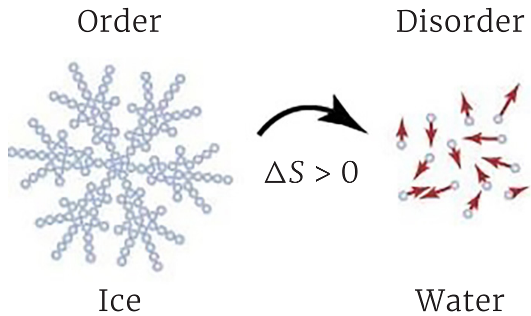

Figure 3. *Increased entropy and disorder*

In summary, the second law of thermodynamics implies that anything that occurs in any part of the world increases entropy in that part of the world!

In statistical mechanics, entropy is defined as $S = k \log(D)$; "log" is the logarithm (for example, $\log(100) = 2$ since $10^2 = 100$), and k is the Boltzmann constant, which is 1.380649×10^{-24} J/K (joules/degrees Kelvin), and D is related to disorder in the system (Van Ness, 1969). This equation can also be written as $S = k \sum -p_i \log(p_i)$, where $\sum$ denotes the sum, and p_i is the probability that a system with countable energetic microstates has n_i particles in state (position and momentum of particles) 'i', or simply the number of particles in state i over the total number of particles ($p_i = n_i / n$).

For example, consider water molecules and their position and momentum within liquid. The definitions of entropy described above are equivalent, but its proof is beyond the scope of this article. For proof, see Van Ness (1969, p. 94). Of interest here, however, are two boundary conditions: minimum and maximum entropy in systems. Entropy is zero in a crystal, as the particles are arranged in a fixed pattern, and only one state exists, which can be determined by $p_i = 1$. Note that $\log(1) = 0$ ($10^0 = 1$), and thus the sum above will equal zero. On the other hand, entropy is at its maximum when the system approaches thermodynamic equilibrium – that is, when all the energy in the system has been exhausted, and the temperature in the system is uniform. The system is then left in a completely unpredictable state, with state probabilities all being equal – that is, every state is equally likely resulting in maximum entropy. The sum is maximized when all probabilities are equal. In other words, entropy reaches its maximum when the system decays and no longer has enough energy to produce work, resulting in thermodynamic death. Throughout this article, the word entropy can be understood to mean disorder, chaos, uncertainty, unpredictability, and uncountability.

In his 1944 publication *What is Life?*, Erwin Schrödinger (1967), the Nobel prize laureate in physics, introduced the concept of negative entropy and declared that life feeds on negative entropy (or negentropy). As discussed above, entropy is not negative, and this is guaranteed by the second law of thermodynamics. In other words, entropy always increases in isolated systems. If entropy is reduced in a system, it must increase somewhere else, and the net result is always positive. Schrödinger was referring to order when he wrote about negative entropy. Thus, if entropy is a measure of disorder, then negative entropy is a measure of order (Schrödinger, 1967). Mathematically, we can write $-S = k \log(1 / D)$, since $\log(D) = -\log(1 / D)$. Therefore, if "D" is the measure of disorder, then "$1 / D$" is the measure of order. Thus, in an open system that is not isolated, it is possible for entropy to decrease via the exchange of energy and matter. This reduction of entropy within the system results in an increase of entropy outside the system. Thus, according to Schrödinger, life is based on reducing entropy within the living organism.

Schrödinger argued that by exchanging energy and matter, and through the process of assimilation, the living organism (an open, dynamic, and complex system) can decrease its internal entropy. Excess entropy is discharged from the living organism through heat, work, and the expulsion of waste after energy has been absorbed. The organism can then continue to thrive as long as it can maintain the condition of negative entropy (decreasing entropy relative to the surrounding environment). In other words, the living organism avoids increasing entropy (disorder) by continuously absorbing order (negative entropy) from its environment (Schrödinger, 1967). However, nothing escapes the second law of thermodynamics, which will eventually take over as the organism decays, reaches thermodynamic equilibrium, and dies (see del Castillo and Vera-Cruz, 2011). Recently, there has also been renewed interest in Schrödinger's controversial theory within the field of somatic psychotherapy (Ferri & Cimini, 2021).

In biology, the conditions for life described above are associated with biological homeostasis – the ability of an organism to maintain internal equilibrium. It can also refer to the organism's ability to remain within its optimal range of function despite changing environmental conditions. Here, I will focus only on the thermodynamic view of life for reasons that will become apparent below – namely, if the soma thrives on feeding negative entropy (reducing entropy within the organism), so should the psyche! From this point on, the word entropy should be understood to connote disorder, uncertainty, and unpredictability.

In two recent books that have very recently come to my attention, I was interested to see Damasio (2021) and Solms (2021) also discuss, respectively, homeostasis and the free energy principle. The free energy principle is closely related to the concepts presented in this paper, which I independently developed. According to Solms, he and Damasio had a heated discussion about their somewhat differing ideas about consciousness in Damasio's office (Solms, 2021, p. 154), which might have provided the impetus for their books on the subject.

Entropy and Information

In the late 1940s, Claude Shannon, the father of information theory, was working at Bell Laboratories (where I also worked early in my career). There, he investigated the loss of information (energy) in telephone lines. He formulated and modeled information loss, and referred to it as the "uncertainty function." Later, John von Neumann, the mathematician and father of modern computer architecture, correlated Shannon's uncertainty function to the thermodynamic concept of entropy, and encouraged Shannon to call his uncertainty function entropy. In "A Mathematical Theory of Communication," published in *Bell Systems Technical Journal*, Shannon formally introduced the concept of information theory (Shannon, 1948).

According to information theory, the information contained in an event's occurrence is inversely proportional to its probability of occurrence, p (a number between 0 and 1). Thus, the more likely the occurrence of an event, the less information the event contains. Conversely, the less likely the occurrence of an event, the more information it contains. For instance, the sentence *"There is at least one rainy day in a year"* contains very little information, since the assertion is very likely to be valid. But *"It will rain tomorrow"* carries much more information, as it is less likely that it will rain tomorrow than that there will be one rainy day in a year. In other words, events that are predictable contain less information, while unpredictable events contain more information. Interested readers may already discern the connection between thermodynamic entropy and Shannon's notion of entropy.

Shannon (1948) quantified the information 'I' contained in an event with probability 'p' (a number between 0 and 1), according to this formula:

$$I = \log(1/p)$$

Where 'log' is logarithm in base 2 (a quantity representing the power to which a fixed number – the base – must be raised to produce a given number; for example, log (8) in base 2 is 3, since 2 to the power of 3 is 8). The information 'I' is measured in bits. Shannon (1948) formally introduced the concept of entropy, which measures the information content of an event, E, that contains n outcomes. Entropy is simply the statistical average of information 'I' contained in the occurrence of each outcome of event E. Entropy, H is defined as:

$$H = \sum p_i \log(1/p_i)$$

where $\sum$ is the summation over all values of i. Shannon (1948) also introduced the concept of mutual information $I(X; Y)$, which is a measure that indicates how much uncertainty is reduced relative to the occurrence of event X, given that a related event Y has occurred. Or, $I(X; Y)$ indicates how much information Y provides about X (Pierce, 1980).

$$I(X; Y) = H(X) - H(X \mid Y)$$

$H(X \mid Y)$ is the conditional entropy (uncertainty) of event X, given that event Y has occurred. Mutual information is also measured in bits.

Shannon (1948) computed the channel capacity C as the maximum amount of information that can be transmitted through a channel. An implication of channel capacity, as applied to the brain's sensory information processing, is that sensory information encoding must be efficient, and that neurons must be expressing their full output capacity in order to encode sensory information (with little loss), subject to the limits imposed by channel capacity. In the field of neuroscience and information theory, this is known as the efficient coding hypothesis. Loh and Bartulovic (2014, p. 1) write: "The Efficient Coding Hypothesis, suggests that sensory relays recode sensory messages, so that their redundancy is reduced, but little information is lost. Coding to reduce redundancy eliminates wasteful neural activity, and also organizes sensory information such that an internal model of the environment causing the past sensory inputs to built up, while the current sensory situation is represented in a way that simplifies the task of the part of the nervous system which is responsible for learning and conditioning."

The efficient coding hypothesis, also known as the redundancy reducing hypothesis, was introduced by Horace Barlow (1961). "If biological systems must minimize their entropy, and entropy is the average information, then it follows that they must keep the flow of information they process to a minimum" (Solms, 2021, p 172). Solms (2021, p. 172) writes further: "Self-organizing systems must minimize information flow, because increasing information demand implies increasing uncertainty in the predictive model. Uncertainty yields surprises, which are bad for us biological systems because they can be dangerous."

Barlow (1961) argued that laws of nature bring order and simplicity to our complex sensory experiences (lower entropy). He further argued that the brain's communication and coding of information should be fast, precise, and minimally redundant (efficient), and should work regardless of interference in the communication channel. The associativity of memories can be considered a direct corollary of Barlow's hypothesis, since by encoding associated (correlated) information together, redundancy is reduced, as memories are not encoded in separate and redundant parts. Another corollary of Barlow's hypothesis is that when a memory is recalled, all associated previously encoded memories are also primed for recall, and thus the constituent neural networks have a higher probability of becoming activated. Redundancy in information theory is defined as (Pierce, 1980):

$$R = 1 - \frac{I}{C}$$

Where 'R' is a measure of redundancy, 'I' is mutual information, and 'C' is the channel capacity, which is fixed and depends on the nature and characteristics of the channel. In this formula, it is clear that redundancy is minimized when mutual information is maximized – which essentially means that the goal of the nervous system is to maximize information about the environment (more predictable; lower entropy). We can readily observe that mutual information, $I(X; Y)$, is maximized when conditional entropy $H(X \mid Y)$ is minimized. $H(X \mid Y)$ is minimized when our uncertainty about the occurrence of event X is minimized, given that event Y has occurred in the past. Conditional entropy $H(X \mid Y)$ is reduced when event X in the present bears some resemblance to event Y in the past, which exists in memory – in other words, when events X and Y are highly correlated. It is also important to note that the brain does not simply compute the correlation between sensory inputs corresponding to event X and events Y that occurred in the past. It begins the computation with events that have higher information content (higher entropy) that are more significant. Not only do neuroscience and information theory prove this assertion, but it is also important to note that this would have had significant evolutionary advantages, in that previously encoded events with high information content were generally more important and more relevant to the survival of our species.

A corollary of Barlow's hypothesis is that our nervous system moves toward predictability, and avoids "high entropy" and unpredictability. Thus, the nervous system feeds on negative entropy, in the information theoretic sense. Viewed rather simplistically, our brain can be thought of as an information processing machine constantly trying to reduce unpredictability by correlating and comparing sensory input to encoded past events with high information content (entropy), and finding the closest match for a response – thus increasing mutual information and reducing redundancy in encoding sensory input. Pfaff (2006) relates brain arousal and emotion to information and entropy, thus indicating that by their very nature, emotionally significant events contain more information and are more unpredictable.

The efficient coding hypothesis can thus be seen as in complete accord with my hypothesis that if the soma feeds on negative entropy, so does the psyche. In other words, the psyche feeds on the reduction of information (negative entropy).

Information and Emotions

What are emotions? All living organisms, from single-celled amoebae to humans, are born with innate abilities that evolved to solve the basic challenges of life (lower entropy – increase order). These challenges include finding sources of energy; incorporating, consuming, and transforming energy and matter; maintaining internal biochemical balance; repairing damage to maintain structure; and defending against external threats (Damasio, 2000). Complex living systems tend to move toward homeostasis (lower entropy); that is, toward self-regulation and stability (Avery, 2012).

At the very bottom of the evolutionary ladder, we find single-celled organisms with simple processes that promote homeostasis – including approaching or withdrawing from an object, assimilating nutrients, and discharging waste. As we move up the ladder to multicellular organisms, we find more complicated processes leading organisms to homeostasis. From primitive to complex, these processes include metabolic regulation, basic reflexes, immune responses, pain and pleasure behavior, drive and motivation, emotion, and feeling (Damasio, 2000). Note that these processes leading to biological homeostasis also reduce the organism's entropy. For the purposes of this article, I am primarily concerned with drive, motivation, emotion, and feeling.

Drive and Motivation

Drive and motivation propel the organism to exchange matter and energy with its environment, to assimilate nutrients, to reduce inner tension, to explore the environment in order to avoid danger and overcome obstacles, and (in humans and other mammals) to seek objects for connection and contact. Thus, the goal of drives is not solely achieving satisfaction or seeking objects, but reducing entropy within the organism. Solms (2021, p. 177) writes: "The fundamental driving force behind the volitional behavior of all life forms is that they are obligated to minimize their own free energy. This principle governs everything they do." Minimizing free energy (Solms, 2021; Friston, 2009) is equivalent to maximizing mutual information between sensory input and the organism's internal states (stimulus and response). Interested readers can thus readily see the relationship between the free energy concept and the efficient coding hypothesis (Barlow, 1961), as discussed above.

In evolution, older systems are never replaced; they are simply modified and/or augmented with new systems. Emotions sit atop processes that promote homeostasis. We can thus say that emotions are biologically determined, and use the body as their vessel. Emotions play a regulatory role in the body, and are crucial in helping higher organisms maintain life (Damasio, 2000). In summary, emotions are part of an array of biological tools that higher organisms (humans and other mammals) use to regulate life. They play a fundamental role in steering higher organisms toward homeostasis (Damasio, 2000). In their simplest form, emotions correspond to energetic states of the body. They occur in the body as autonomic responses to external stimuli. However, bodily states (emotions) can also be created through the recall of memories, which Damasio (2000) calls the "as if" loops.

Based on the hypotheses presented in this article, emotions are fundamentally autonomic bodily responses to high entropy (unpredictable – novel) external environmental stimuli. As such, they represent increased entropy within the unitary psychosomatic structure; emotions are thus equivalent to entropy. In order for an organism to return to homeostasis, excess entropy (emotion) needs to be reduced and processed. In mammals, this reduction is primarily achieved through the body. Emotion (entropy) is processed and discharged predominantly through expression and by taking action. Mammals typically discharge residual energy related to emotion (entropy) by vibration, or other bodily mechanisms. *Homo sapiens* are endowed with the ability to block the expression of emotions to a certain extent (thus increasing entropy within the psychosomatic structure). How do these blocked emotions get released? The short answer is feelings!

Panksepp (1998), Damasio (2000, 1994), and LeDoux (2015) all agree that emotions are different from feelings. Feelings require conscious awareness, while emotions occur outside conscious control. The authors differ on the mechanisms of emotion and feeling, but agree that feelings require cognitive awareness, and are essentially limited to *Homo sapiens*. During the course of evolution, feelings resulted in enhanced emotional processing and perception within the human brain.

However, I posit that feelings serve another very important purpose: when accompanied by intention and full conscious awareness, they result in the discharge of residual emotion. As practitioners of mindfulness know, if we become mindful of an emotion (consciously aware), it will fade away and a state of temporary homeostasis may result. Siegel (2015) also indicates that emotions will weaken after 90 seconds if observed (felt). The role of feelings in processing and discharging emotion thus becomes clear. However, if emotion rises above a certain threshold (very high entropy), then the brain's cognitive structures are no longer fully available to process and discharge emotion. In that case, some degree of emotion may need to be discharged through the body via expression, vibration, or other means before we can become consciously fully aware (feel) – which can then result in further discharge. Thus, an important role of feelings is to bring the organism back to homeostasis by discharging residual emotion and lowering entropy within the body. "After all, one of the foundations of consciousness is feeling, whose purpose it is to assist with the governance of life in line with homeostatic requirements" (Damasio, 2021, p. 131).

This assertion is valid for positive as well as negative emotions. In their most general sense, pain and pleasure are not emotions (LeDoux, 2015). They correspond to conditions of high and low entropy within the body. When the organism cannot efficiently manage its internal entropy, entropy will increase, which causes the body to react (possibly by contraction), which in turn causes pain and discomfort. On the other hand, pleasure is related to lower entropy and to expansion of the body (Reich, 1980, & Lowen, 1994). "The overall profiles and ease and relaxation contribute to feelings that we designate by such terms as well-being and pleasure; the contraction and strangulation patterns produce what we call discomfort and malaise. … and the extreme discomfort that we designate as pain" (Damasio, 2021, p. 90).

Of course, practitioners of somatic psychotherapy have always implicitly known the importance of self-regulation (Reich, 1980), which is equivalent to lowering entropy, and maintaining low entropy, within the unitary psychosomatic structure. They also know that without emotional regulation (the ability to reduce entropy), self-regulation is not really possible. Somatic psychotherapists know that self-regulation occurs when the body is motile and relaxed, when breathing is full, when the musculoskeletal structure is aligned, when the eyes shine, when skin color and hue reflect full blood flow to the surface of body, and when emotions are felt (Lowen, 1994). On the psyche's side, the sense of self is strong, the voice is resonant, and spoken words and thoughts are embodied and connected to feelings (Lowen, 1994).

A Technique

This hypothesis immediately lends itself to a technique to discharge excess emotion (entropy). Its effectiveness is based on clients having proprioception – the ability to sense their body – as well as a strong sense of self. When clients experience a strong emotion related to a lingering stimulus, I first ask where they sense the emotion in their body. Once they can successfully identify the emotion's location, I ask them to imagine a container that encapsulates the emotion in their body, and extends a little beyond, so they can observe the inside of the container in front of them. I then ask them to place their awareness on that container (to feel it) and not think about anything . After a few minutes, clients generally feel the container becoming smaller, while its content also becomes smaller and more distant. I then ask them to imagine that the container has a small, capped hole at the bottom. I ask them to remove the cap from the hole, and let the residual energy (emotion) discharge down through their legs and toes and into the ground. This exercise usually results in the successful discharge of residual emotions (entropy). I have used it many times with good results. Interested readers will note the similarity between this technique and a simplified version of Gendlin's focusing (Gendlin, 1982). The theory I propose here thus also explains why focusing is effective, and how it works in situations where emotions are not too overwhelming.

Case Study

Sue has been seeing me for about a year. One day, she came in and complained about an argument she had with her mother. She was just feeling "bad," and this bad feeling was lingering and not going away. I inquired about her sense of feeling "bad.'' After a bit of analysis, she realized she was feeling a mix of anger, guilt, anxiety, as well as sadness. I asked Sue to tell me where in her body she felt these emotions, and she indicated they were centered around her chest. I then asked her to imagine a container that fully encompassed these emotions, and was large enough that she could look inside. I asked her to just observe the interior of the container with awareness, and let thoughts come and go without dwelling on them. After a few minutes, I sensed that something had shifted, and asked her about the container and its content. She indicated that the container seemed smaller, and so did the content. I then asked her to imagine that the container was capped at the bottom, and to open the cap and let the rest of the content discharge through her body down to the ground. After doing so, she felt the "bad" feeling was gone, and she was no longer carrying that emotional load. Once Sue was relatively free of the excess emotion related to her argument with her mother, we were able to explore their relational conflicts.

Relational Trauma

At birth, infants begin their life journey. This is the first period in the life of the neonate, referred to as normal autism (Mahler, 1975), the autoerotic phase prior to primary narcissism (Freud, 2012), or the schizoid stage (Lowen, 1994). In terms of object relations, this stage is objectless; infants' drives are focused on themselves (autoeroticism). This lasts for about a month. At the end of this period, infants, if safe , have formed a relatively integrated image of their body. For example, they know that their limbs belong to them.

At the beginning of the second month, which corresponds to the symbiotic stage (Mahler, 1975) or the first half of the oral stage (Lowen, 1994), infants face existential anxiety and fear. In object relations terms, this period is pre-object. Infants' drives are mostly focused on the need for satisfying part-objects (such as the breast), and infants experience their mother's functioning as part of themselves (the symbiotic stage). Disorders related to these periods are beyond the current scope of this article, and will not be discussed.

Full object relations begin at the end of the symbiotic phase, which ends at around five months of age. Infants begin to differentiate themselves from their mother, and begin to distance by pushing her away when being held in her arms. This is Mahler's differentiation subphase (Maher, 1975) or the second half of the oral period (Lowen, 1994). At this point, infants fear not having the object (mother) in their vicinity, and at the same time want to differentiate from her. Drives during this and subsequent periods are focused on the object for support and safety, as well as on exploring the environment. In either case, and as previously discussed, drives serve to reduce infants' internal entropy by seeking proximity, and their external entropy by exploring their environment. Infants' needs are partially met and partially frustrated. The frustration of their needs results in higher tension (entropy) within. In order to gain some control over their environment and be able to predict it (to reduce entropy), infants must adapt to this situation. They consequently form neural pathways that resemble those of their mother (the unsatisfying object) in order to predict and conform to their environment. They thus internalize the "bad" mother in order to reduce uncertainty (anxiety) within their environment, and in so doing, their immediate needs for the mother are reduced as well. The "bad" internalized mother has two facets; on the one hand, it allures but does not satisfy, and on the other, it frustrates and rejects!

This is an intolerable situation, and to manage it, infants split the internalized "bad" mother into the needed or exciting object that allures but does not satisfy, and the frustrating or rejecting object. Infants will seek the exciting object (EO) throughout their life by seeking fuller human connection, thus reducing entropy within their unitary psychosomatic structure. The ego maintains a libidinal attachment to this internalized excit-

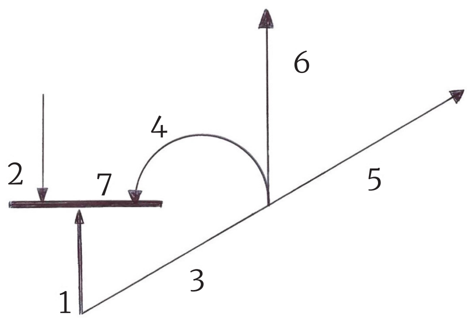

Figure 4. *Relational trauma*

ing object, resulting in a split within the ego. Fairbairn (1952) calls the endopsychic structure resulting from this split the libidinal ego. Recall that at the end of the differentiation subphase (Mahler, 1975), or the end of the oral stage (Lowen, 1994), infants' drives shift more toward exploration of their environment, as they have developed the capacity for locomotion. At this point, children move further away from the mother, and are increasingly absorbed in their own activities and less aware of the mother. This period coincides with Mahler's practicing period (Mahler, 1975) or Lowen's narcissistic stage (Lowen, 1994).

At this point, infants' exploratory drives may face environmental negativity and rejection. In other words, their drives may be thwarted by the mother (bad object), which in turn increases entropy by increasing infants' anxiety, as they feel their exploratory drives being blocked and their connection with the still-needed mother weakening. To reduce entropy (anxiety), children choose a similar strategy as before. They form neural pathways based on their experience with their mother, and in effect block and redirect their own drives so as to conform to their environment and the limitations imposed on them by the mother (bad object). They internalize and identify (identification is a stronger form of internalization) with their mother in order to reduce uncertainty (entropy) in their environment and gain some level of control over it.

This is the rejecting and frustrating aspect of the "bad" object (rejecting object – RO). As with the exciting object, the ego maintains a libidinal attachment to the rejecting object, which results in a further split within the ego. Fairbairn (1952) calls this endopsychic structure the anti-libidinal ego or internal saboteur. He contended that good aspects of objects are not internalized, but are simply enjoyed, resulting in healthy ego development (Guntrip, 1973). It is important to note that new neural pathways also form based on positive experiences and satisfying relationships with good objects. These newly formed neural pathways, based on positive experiences with the object, serve as ways of keeping entropy (uncertainty) low.

I suggest that these newly developed neural networks also represent a form of internalization, as they resemble those of the good object. We know that the brain wires through experience, and this phenomenon is observed in therapy, as clients have good experiences with the therapist and form new neural pathways similar to those of the therapist. These newly formed pathways support new coping mechanisms and new effective approaches to life's challenges, thus reducing entropy.

However, residues of the original drives still remain as the "I" that relates to the environment and to people in the outside world. Fairbairn (1952) called this endopsychic structure the central ego (CE), which forms as drives are shaped by the reality principle. The ego is mostly conscious, but may also contain unconscious elements and aspects of original drives. It is, however, weak and ungrounded, as some of its energy has been consumed, limited, and shaped by the libidinal and antilibidinal egos. Its approach to its environment and objects may be tentative and cautious. Increased entropy, which can be experienced as a partial loss of the sense of self due to weakness and lack of grounding, can be somewhat ameliorated by mirroring self-objects, idealizing self-objects, or twinship self-objects (Kohut, 1971). A self-object is the experience of an object (person) as part of the self. This represents the narcissistic line of development, the focus of self-psychology (Kohut, 1971).

The tentativeness and caution of the central ego are related to perceived higher entropy and uncertainty within the environment, and the ego's relative inability to approach and withdraw effectively. Individuals can reduce entropy by finding objects that mirror them and reflect a sense of self-worth and self-value (mirroring self-objects), by finding people who help calm and comfort them (idealizing self-objects), or by finding those who give them a sense of alikeness – twinship self-objects (Kohut, 1971).

In Figure 4, I depict the process of relational trauma in a model adopted from Wilhelm Reich (1980). A simpler form of this diagram was discussed in detail by Hilton (2008). Here, segment 1 represents the unitary drive, as previously defined. The drive may face frustration, rejection, or environmental negativity, as represented by segment 2. Segment 3 represents the new direction taken by the drive. Identification with the rejecting aspects of the object is represented in segment 4 (antilibidinal ego), and seeking the needed and exciting aspects of the object is represented in segment 5 (libidinal ego). Segment 6 represents the central ego (CE). The muscular armor, which keeps the original drive in check, is represented by segment 7.

For the most part, the strategy used in childhood to reduce psychic entropy has the opposite effect during adulthood. Fairbairn (1952) contended that in order for clients to risk releasing bad objects from their unconscious, they need to feel safe in the therapy setting, and see their therapists as good objects before they can become vulnerable and function beneath their defenses as their brain forms new neural pathways. They can then overcome their resistance to releasing bad objects from their unconscious. Releasing the bad objects and internalizing the good objects support the true self (related to segment 1 in Figure 4). The true self (segment 1 in Figure 4) may replace the endopsychic structures, although residues always remain. Recall that Wilhelm Reich (1980) asserted that psychoanalysis is about consistent analysis of transference and resistance. Transference and resistance are simply the persistent activation of old neural networks. Consistent analysis of transference and resistance is necessary to successfully release and dissolve endopsychic structures, since formation of new neural pathways is based on new experience with the therapist. Once bad objects are released from the unconscious, the conflict (high entropy) between the true self (segment 1 in figure 4) and its internalized bad objects is diminished, thus reducing entropy.

Guntrip (1973) posited that the client's primary nature (segment 1 in Figure 4), which was repressed and arrested in development, needed to be strengthened – not the central ego. At this point, the real self, for the most part, replaces the central ego, which in the past needed the self-objects to maintain a weak sense of self.

The release of bad objects is a lengthy process. We must analyze and work through the transference and resistance while new neural networks form, based on new experiences in relationship with the therapist. As previously noted, once clients internalize the therapist as the good object, they can risk releasing internalized bad objects. Internalizing contact with the good object will occur over time. Once the contact with the good object is internalized, clients do not need the presence of the therapist (good object) any longer. During stressful times, however, contact with good objects may be necessary for self-regulation and reduction of entropy within the unitary psychosomatic structure. Interested readers should note that my description of object relations differs slightly from Fairbairn's original formulation (1952).

To shorten the process, and for clients to experience how it feels to temporarily let go of internal bad objects, I designed the following technique.

The Technique

Before describing the technique, I must mention that it is predicated on clients having a relatively strong ego so that the process of contact and connection with their own body and with me *is not threatening and not retraumatizing*. This exercise is contraindicated for clients who cannot connect with and feel their body, and/or have a diminished sense of self. Clients must first be able to connect with their body for this exercise to be effective.

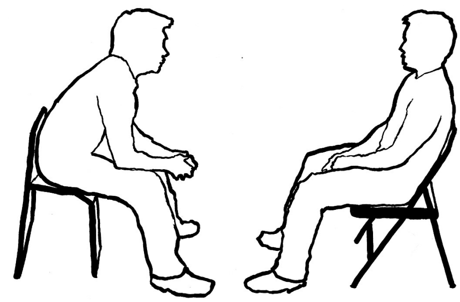

Figure 5. *Working with relational trauma*

In Figure 5, I show the process of working with relational trauma. Throughout the process, I invite clients to release thoughts. I pull my chair a bit closer to them and ask them to remain aware of their body (from their neck down, to avoid staying in their heads) and breathe normally. I may have to coach clients in staying aware of their bodies. Being aware of the body is the somatic correlate of the sense of self. Once clients are aware of their body, I then ask them to remain in contact with me. Frequently, I have to coach clients how to stay in contact with me. I maintain gentle eye contact with them and look at their left eye, and ask them to gently look at my left eye so we can make a right-brain to right-brain connection (the left eye is connected to the right brain, and the right eye is connected to the left brain). I also ask them to be aware of the space (distance) between us (to feel the connection), and I do the same (become aware of the space between them and me). Feeling and awareness of the space between us can be conceived as the somatic correlate of the connection. This step makes clients aware of the presence of the good object, which is felt at the somatic level. I then ask them to remain aware of their body as well as simultaneously maintaining contact with me. After a bit of practice, clients can follow these steps. Throughout the exercise, clients remain silent and simply stay in contact with themselves and with me. For this step to be effective, clients must have reached a certain level of ego strength, and a certain degree of trust within the therapeutic relationship in order to become vulnerable, and drop their defenses and resistance.

After a minute or two, or when I feel it is appropriate to go to the next phase, I ask them to close their eyes and imagine I am getting closer to them (as close as they are comfortable), until they experience my energetic presence in their body. I then ask them to stay with their sensations and feelings for about a minute or two, until I sense that they feel their contact with me in their body. I suggest this last step is the somatic correlate of internalization.

Through this energetic and somatic exercise, clients first connect with themselves, then to the therapist, and finally they internalize the contact. Afterwards, clients typically feel much calmer and feel a deeper connection with me and their bodies. They report that they are able to self-soothe between sessions when they feel emotionally overwhelmed. Again, connecting with and internalizing the good object is a lengthy process. This exercise may shorten it by creating a psychological imprint, through the new neural networks (initially weak) that form during the exercise. Future therapeutic work is then built upon strengthening these newly-formed neural networks.

Case Study – Nancy

Nancy, a woman in her thirties, had been working with me for nearly two years. She came to see me because of anxiety. She felt estranged from her husband, whom she described as cold and narcissistic. She believed that her husband was having an affair. Nancy had no support system, and felt lonely. She said that even the thought of leaving her husband would dramatically increase her anxiety. In terms of relational trauma, her libidinal ego could not give up the needed object (the exciting object, her husband). Over time, she developed a strong therapeutic connection with me, but the connection with herself was not very strong, and she thus felt powerless. About a year into our work, I decided to do the aforementioned exercise with her. I asked her to not think throughout the exercise, and to close her eyes and feel her own body from her neck down to her toes. When she was ready, I asked her to open her eyes and connect with me by simultaneously looking at my left eye and also putting her awareness on the space between us. After a few minutes, when I felt that she was connected with herself and with me, and that she was calmer, I asked her to close her eyes and imagine that I was getting closer to her, and to bring me as close to her as she felt comfortable, so that she could feel my energetic presence and stay with that. After a few minutes, I asked her to slowly open her eyes and stay in contact with herself (to feel her body). I then asked how she felt. She said she felt calm. I asked if she still felt lonely and anxious. She immediately said “no”. I explained the purpose of the exercise. In a calm tone, Nancy said she wanted to feel this way “all the time.” I told her this was our therapeutic goal, and that she now knew this place, and that her limbic system and frontal cortex had an imprint of how she felt when she was connected to herself and to me. We did the exercise several times over the course of her work. She made significant progress over time. Recently, Nancy mentioned that she felt very empowered, that her anxiety had lessened, and that she felt she had many choices and was no longer a prisoner of her fear.

Shock Trauma

When the brain’s information processing ability cannot keep up with high entropy external stimuli (events), the result is shock trauma. The memory of the traumatic event will not be consolidated in cohesive form, but will likely be fragmented, with missing parts. I previously discussed that according to the efficient coding hypothesis, the brain maximizes mutual information between stimulus and response. Recall that mutual information is $I(X; Y) = H(X) - H(X \mid Y)$, and that mutual information between X and Y is how much information Y provides about X, or how much the uncertainty about X is reduced, given that Y has occurred.

Let X be the response to a stimulus correlated to a traumatic event that resulted in response Y in the past. $H(X \mid Y)$ is the conditional entropy of response X, given the event with response Y. Mutual information is maximized when $H(X \mid Y)$ is minimized. $H(X \mid Y)$ is minimized when response X is highly correlated to Y. In other words, the efficient coding hypothesis implies that response X to a present event will be similar to response Y to a correlated past traumatic event (the repetition compulsion). We can successfully treat trauma if we can minimize mutual information – in which case, response Y to a traumatic event in the past will not result in a similar response in the present. That is, the present event will be treated as novel, resulting in a different response.

In information theory, conditional mutual information is defined as $I(X; Y \mid Z) = H(X \mid Z) - H(X \mid Y, Z)$ (Pierce, 1980). The interpretation of conditional mutual information is how much information Y provides about X, given that Z has occurred, or how much Y reduces uncertainty about X, given that Z has occurred. Let X and Y be defined as indicated above; let Z be a new event that has occurred. If event Z results in minimizing conditional mutual information, then response Y will clearly not lower the entropy of response X, and the individual will thus have a range of response choices that may not be correlated to Y. We can make the notation more precise by writing the equation in this form:

$$I(X \mid Y = y, Z = z_i) = H(X \mid Z = z_i) - H(X \mid Y = y, Z = z_i)$$

Here, ‘y’ is the specific traumatic response to an event in the past, and ‘z_i’ is the specific added event in the ensemble (set) ‘Z’. Thus, mathematically speaking, the treatment of trauma could be framed as an optimization problem of choosing the “right” event ‘z_i’ that occurred in the past, which minimizes conditional mutual information.

Consider the following example. Every year, Bob, a middle-aged man, vacations at a remote island. He sometimes goes fishing during his stay. He needs to know what the weather is like before going fishing, but the only weather report for the island is provided by a local man who can predict the weather with 90% (0.9 probability) certainty. Bob trusts his prediction, and plans accordingly. When he returns to the island the following year and looks for the local weather forecaster, he is told the man had a stroke, and is 50% (0.5 probability) cognitively impaired. Can Bob continue to plan his fishing excursions? It is easy to see that the answer is NO!

Let X be Bob's uncertainty about the weather (clear or stormy), let Y be the local forecaster's response, and let $Z = z$ be the new information: the local forecaster has had a stroke. It is clear that before the forecaster's stroke, Y maximized mutual information between X and Y. $I(X; Y) = H(X) - H(X \mid Y)$. Note that $H(X)$ is the uncertainty about X (clear or stormy). And $H(X \mid Y)$ is very small, as Y with probability 0.9 (90%) predicts X. Thus, conditional entropy is close to zero, which means that mutual information is maximized. Note that if X has a probability of 0.5, the forecaster's weather prediction is similar to tossing a coin. If the forecaster can predict the weather with a probability of 1 (100%), then Y provides 1 bit of information about X (clear or stormy – 0 or 1 requiring only one bit), since $H(X) = 1$, and $H(X \mid Y) = 0$ (Y completely determines X).

Let us now consider the added information that the local forecaster had a stroke. Recall that conditional mutual information is $I(X; Y \mid Z = z) = H(X \mid Z = z) - H(X \mid Y, Z = z)$. Since the local forecaster's cognitive impairment is 50% (probability 0.5), then $H(X \mid Z = z) = H(X)$. In other words, Bob's uncertainty about the weather does not change, given that the local forecaster had a stroke. On the other hand, $H(X \mid Y, Z = z)$ is maximized, since Bob's uncertainty about the weather does not change very much – given that the forecaster predicted the weather, and given that he had a stroke resulting in 50% cognitive decline. That is, his prediction is as good as tossing a coin! Therefore $H(X \mid Y, Z = z)$ is very close to $H(X)$. We thus see that in this case conditional mutual information is minimized. Also note that since the probabilities are known in this example, mutual information and conditional mutual information can be computed.

My interest in the nature of traumatic memories began in 2012. In particular, I was curious about the controversy within the somatic psychotherapy community related to Janet's (van der Kolk, 1994) and Freud's (1952) views regarding the nature of traumatic memories, and whether traumatic memories were dissociated (Janet) or repressed (Freud). Although van der Kolk had initially sided with Janet in this old debate, he later revised his views (van der Kolk, 2014). Using information theoretic neuroscience results, Shahri (2017) showed that traumatic memories were neither fully repressed nor fully dissociated. When processing the information associated with the traumatic event was beyond the brain's capacity (very high entropy), the result was dissociation. Otherwise, these aversive memories were repressed, and encoded as implicit memories that dominated the individual's behavior in more subtle ways (Shahri, 2017).

In 2016, I became inspired by the recent works of LeDoux (1996, 2002), who posited that it should be possible to alter traumatic memories during the reconsolidation window. In 2017, while continuing my research on revising traumatic memory, I came across the latest findings from LeDoux's laboratory. Late in 2017, while working with my former therapist Dr. Robert Hilton, I stumbled upon a way of modifying traumatic memories, which later evolved into a technique based on information theoretic neuroscience and research results from LeDoux's lab (Shahri, 2018). Below, I present more advanced versions of the technique, which can erase the emotional content of traumatic memories. Independently, Ecker, Ticic, & Hulley (2012) discussed the application of the findings from LeDoux's lab in modifying traumatic memories, which I discuss next.

Daniela Schiller et al. (2009), researchers at LeDoux's lab, found that during reconsolidation, memories go through a period of instability after being recalled. They also introduced a behavioral technique to target reconsolidation of fearful memories in humans. They demonstrated that traumatic memories can be associated with benign information provided during the reconsolidation window. They showed that, as a consequence of this association, fearful responses to traumatic memories were no longer expressed. They indicated that this effect lasted for at least a year, and affected only the reactivated relevant memories. In a separate study at LeDoux's lab (Diaz-Mataix, et al., 2013), researchers indicated that while in the labile (unstable) state, which lasts about five hours (Ecker, 2015a, 2015b), the emotional content of traumatic memories can be modified by introducing new information during the reconsolidation window, while leaving autobiographical memories essentially unchanged (Ecker, 2015a, 2015b).

To reiterate, LeDoux's lab research indicates that the emotional content of traumatic memories can be altered by introducing additional information that contradicts or augments the original memory while it is labile (unstable), a phase that lasts about five hours, and takes place before reconsolidation is complete. The new information can erase the emotional content of the traumatic memory, while leaving its autobiographical aspects fairly intact (Ecker, 2015a, 2015b). To be fully effective, however, the new information needs to minimize conditional mutual information, as stated above.

Recall that the emotional aspects of traumatic memories are, for the most part, implicit and encoded in the limbic system (LeDoux, 2015). There is thus no direct way to access implicit traumatic emotional memories verbally; they cannot be processed through introspection. Therefore, alternative interventions may be necessary. Note that the autobiographical aspects of traumatic memories are formed by the hippocampus, and encoded mostly in the prefrontal cortex (Makin, 2017); the amygdala attaches emotional significance (entropy) to autobiographical memories (LeDoux, 2015). Traumatic memories can change when the link between autobiographical memory and its emotional aspects are established, as memories change when they are recalled (LeDoux, 2002) due to association. It is then that the addition of new information can modify the aversive memories during the reconsolidation phase.

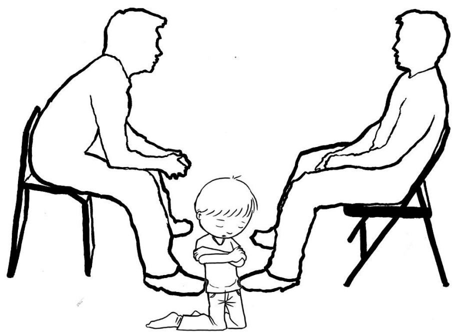

Figure 6. *Working with traumatic memories*

Reconsolidation occurs in everyday life

Alice, a woman in her thirties, dined each week at her favorite restaurant. A few months ago, she ended up with food poisoning, which she attributed to the seafood she ate there. Her symptoms began minutes after she finished her food. After this traumatic experience, whenever she drove by the restaurant or saw/smelled the same food that had made her sick, she became triggered, and her body reacted to her past traumatic experience. At the suggestion of a close and trusted friend, she decided to go to the same restaurant to possibly overcome her aversive reactions. Upon entering the restaurant, she again became triggered. Her trusted friend ordered and ate the same food that had made Alice sick, and did not end up with food poisoning minutes later. It was then that Alice recovered from her aversive reactions to the food and the restaurant.

This example shows that when Alice's memory of the past traumatic experience was activated (autobiographical and emotional), and new information was added, within the reconsolidation window, that contradicted her original memory (expectation) – her trusted friend not getting sick eating the same food – the emotional aspects of Alice's traumatic memory were erased, and she was then free of her aversive traumatic reactions. Had Alice needed to wait for more than five hours before knowing whether her friend would end up with the same fate, her traumatic memory might not have changed, as this would have been outside the reconsolidation window.

The theory presented in this article fully predicts the results from LeDoux's lab. I discussed earlier that the living organism must constantly reduce and maintain entropy to continue its existence and reach biological homeostasis. I also noted that in the case of *Homo sapiens*, the psychological system must also reduce entropy to reach psychological homeostasis. Earlier, I discussed how emotions (which form spontaneously in response to high entropy stimuli) correspond to increased entropy within the psychosomatic system. The psychosomatic system constantly strives to reduce entropy (psychosomatic homeostasis). However, in the case of consolidated traumatic memories, due to fragmented memories of traumatic events or the high emotional charge (entropy) of these events, entropy cannot be easily reduced, as high emotional charge is associated with the traumatic memories.

However, when a memory is recalled while it is labile, if an alternative "low entropy" (benign or predictable) story is introduced that either contradicts the original story or augments it, the psychological system chooses it over the old highly charged (high entropy) memory in order to reduce entropy, and consolidates the new memory during the reconsolidation phase – leaving the original traumatic memory relatively unchanged while erasing its emotional content. After recall, memories are unstable and can change, and the brain chooses an alternative with lower entropy during the reconsolidation process.

High entropy events like traumatic memories require more resources to encode and consolidate, which means that more neural networks are consumed to encode and consolidate them. Recall that memories are associative, and can associate, if correlated, when the constituent neural networks are activated (when recall has occurred). Thus, when a traumatic memory is recalled and alternative partially correlated (lower entropy) new information is added that contradicts or augments it, the brain associates the two stories, but gives higher credence to the new (low entropy) story. It effectively decouples the original traumatic memory from its emotional content (which is essentially erased), and reconsolidates the new story while maintaining knowledge of the original memory (episodic memory). In my experience, the emotional content (energy) of the traumatic memory is usually discharged through a deep breath, soft tears, or some other somatic response.

Next, I present two techniques to alter the emotional content of traumatic memories. The first is mostly applicable to situations in which the memory of the traumatic event is relatively intact, but recalling it is overwhelming and triggering. In the second, I discuss situations in which the memory of the traumatic event is fragmented and disjointed.

The Technique – I

I sit directly across from clients, and invite them to bring the traumatic memory to their attention (recall), as if they are watching someone else going through the trauma. I ask clients to imagine they are safe with me, so that they do not become overwhelmed or activated. I then ask them to stay in contact with their body and with me in the manner described earlier. While remaining aware of our connection, I ask them to look to the left at their imagined self (to access their emotions) by simply turning their eyes, not their head, for perhaps a second; the stronger the emotions related to intrusive memories, the shorter the duration of staying with them. This is done in order to activate their right hemisphere (Figure 6).

By observing the emotional states of their imagined self on the left, clients effectively decouple the emotional aspect of the traumatic memory from the autobiographical (episodic) memory, increasing the efficacy of this technique and the erasure of the aversive emotional memory. I then ask clients to see if an alternative story emerges that contradicts the original story. We continue the exercise until a more benign and empowering story has arisen. At times, I may need to guide clients through creating the new story during the exercise or before they begin.

Throughout the exercise, I ask clients to avoid thinking and stay with their body. Once the new story has taken hold, the emotional state of their imagined self (to their left) also changes, and the emotional aspect of the traumatic memory is erased. Clients always still remember their traumatic memories (autobiographical), but no longer seem to be triggered by them, since their emotional contents are erased, and a more benign (low entropy) alternative story becomes dominant in their memory.

The new story 'z_i' is created in a way that minimizes conditional mutual information. Interestingly, the story chosen can subjectively be seen to minimize conditional mutual information. If not, I usually make suggestions, and guide clients to choose a different story, one that lowers conditional mutual information. The exercise usually lasts only a few minutes. Over the past several years, I have worked with many clients; in every case to date, we have been able to successfully rewrite intrusive traumatic memories, and they have not returned.

Case Study – Mary

Mary, a woman in her late thirties, came to see me a few years ago. Her presenting issue was anxiety. She reported she was using drugs to self-medicate. Her anxiety was largely hidden, but manifested visibly as twitches in her stomach area. Our work proceeded slowly, yet positive transference was established fairly quickly. Six months into her therapy, she mentioned that when she was a teenager, she had been raped by a man who owned a gas station where she worked. It seemed that many of her symptoms were the result of this trauma.

I asked Mary if she was willing to do an exercise, and she affirmed that she was. I asked her to not think during the exercise, but to feel her body, then connect with me, so that she could feel both herself and me simultaneously. I then asked her to picture the traumatic incident at her left, as if she were watching a somewhat foggy and unclear movie (to reduce her emotional arousal) for half a second, and to then come back and connect with me. After about thirty seconds, I asked Mary to allow an alternative story to emerge, one that was safe. She continued the exercise for another minute or so, and I then noticed a change in her emotion that was apparent on her face. I asked her to stop the exercise and connect with me for a little while, which she did. I then asked if an alternative story had emerged. "Yes," she said, and proceeded to tell me that her parents had unexpectedly showed up as the perpetrator was about to attack her. They then called the police, and the man was arrested. I asked her to look at the incident for just a moment to see which story came to mind. She said, "the alternative story." I asked her not to think about the story (old or new) for at least five hours. I checked during our next session to make sure that the new story had reconsolidated, and the result was affirmative. Two years after the intervention, the new story still persisted, and many of Mary's symptoms had diminished.

The second technique is related to situations in which memory of the traumatic event is fragmented and disjointed. In this case, my approach to rewriting the emotional content of traumatic memories is based on adding new information at the time of recalling the traumatic memory so as to fill the gaps in the fragmented memories (augmentation), which then results in its re-encoding during reconsolidation. Re-encoding emotionally charged memories converts these aversive memories, through elaborative repression (Erdelyi, 2006), to more predictable, benign, and less emotionally charged memories. The efficacy of this technique is predicated on a strong therapeutic relationship, which functions as a predictable holding environment and safe container.

To illustrate the next technique, consider Figure 7, where A and B represent two different people. Look at A, then B, and repeat. Since the two pictures are very different, you might notice slight activation within your nervous system (higher entropy) due to the difference between them. Now observe the sequences of pictures at the bottom of Figure 7, one at a time, from left to right, and see if the arousal lessens. The bottom images simply morph picture A into picture B.

The Technique – II

I sit across from the client (Figure 5) and ask them to recall the traumatic memory and observe themselves at their left, as if their imagined self were going through the fragmented traumatic event. However, I ask them to recall it very slowly – one frame at a time (in slow motion). I also ask them to connect with me as needed if the recalled material is overwhelming, and they need to feel my presence and support.

Recalling traumatic memories in this way will be less overwhelming; the brain can process the high information (emotion) content of these memories and add extra information through elaborative repression (Erdelyi, 2006), which fills in the gaps and makes sense of the traumatic memory, thus resulting in integration. My presence with clients and their connection with me

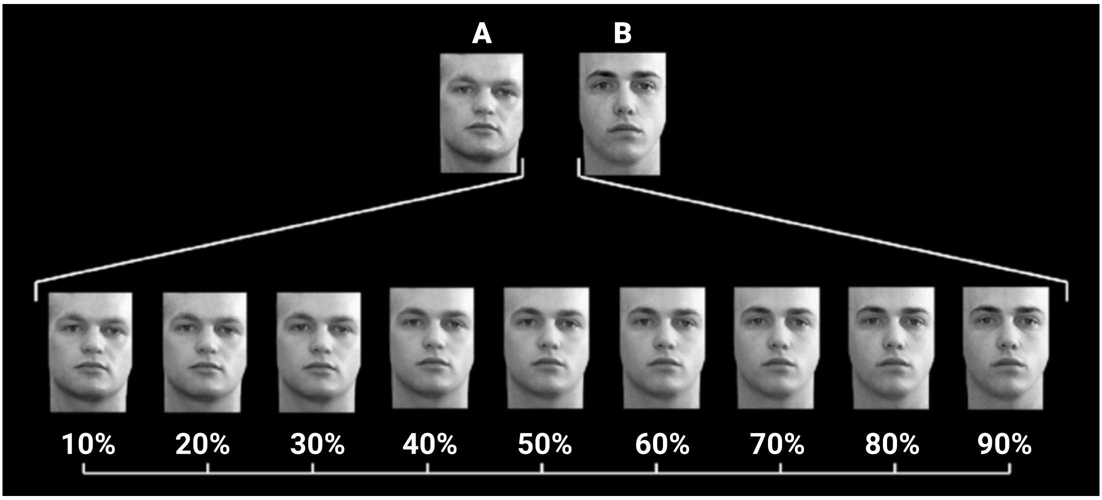

Figure 7. *Filling the gaps*

serves to reduce arousal so the brain can process the recalled memory, and the added information can fill in the gaps in that memory.

When the change has occurred, I can usually observe it on a client's face. When these early memories – the blueprint for much future behavior – are re-encoded and rewritten, clients generally feel freer, and do not function from their early traumas as often and as intensely. With this technique, conditional mutual information is minimized by filling in the gaps. Even though the new and the original story are correlated, the new story has lower entropy. It augments the original story in a way that contradicts the outcome, thus reducing conditional mutual information. It also erases the emotional content of the original traumatic memory.

Case Study – Karen

Karen, a woman in her late forties, had been working with me for a number of years. Her connection with her body was not very strong, and her therapy had progressed very slowly – in general, it was not very successful. She mentioned that she was very afraid of water, and would become anxious when she was even close to a swimming pool. She would also get triggered by the smell of chlorine, a substance often added to swimming pools. I asked how long she had had this symptom. She indicated she had been afraid of water for most of her life. I asked if she remembered anything in her childhood related to water. She recalled that when she was about five, she nearly drowned in a swimming pool at a resort where she and her family were vacationing. She and a few other children were playing in the pool when an older child pushed Karen underwater; she could not breathe and almost drowned. Fortunately, an adult saw that Karen was being held underwater by the older child, and came to her rescue. Her recounting of this story was based mostly on what she had been told by her parents, except for bits and pieces that she remembered. The whole incident had happened very quickly, and she could not remember very much of it. I suspected this was the main cause of her symptoms and her fear of water.

I asked Karen if she was willing to do an exercise, and she responded "yes." I asked her to feel her body to the extent that she could, and to also connect with me, as described above. These were not easy tasks for her, but she was able to do both to some extent. I then proceeded with the exercise, and asked her to watch what happened toward her left, and to come back to her connection with me when she needed to feel safe. I instructed her to slow down her recollection of what happened to "one frame per second." She initially had a hard time with this, as she had no detailed recollection of what had happened. I asked her to just imagine what had happened, and to simply make it amusing and playful by filling in the gaps in her memory.

After a few minutes, I felt she had created an alternative story! She said she imagined that, in a fun way, she was playing with other children, and they would push each other underwater, and then they would push with their feet against the bottom of the pool to come up. She was smiling as she recounted the new story, and felt that it could have been a lot of fun to play that game. This new story persisted when I checked with her during our next session. She indicated that her anxiety about water was essentially gone, and she no longer felt afraid of water – although there were still some knee-jerk reactions, which went away quickly.

Complex trauma

Complex trauma is different from shock trauma, and is characterized by the occurrence of many traumatic events and/or prolonged exposure to traumatic stimuli. Complex trauma can be distinguished from developmental trauma, which is the result of suboptimal childhood experience during different developmental phases.

Complex trauma can affect an individual in many different ways. They might have uncomfortable physical sensations, a constant feeling of sadness, anxiety, shame, fear, confusion, lack of trust, or self-hate. These feelings usually persist in the body, and are not consciously attached to specific events. They are, however, triggered by stimuli with some similarity to past traumatic events. The efficient coding hypothesis (maximum mutual information) nearly guarantees that the response to the present stimulus will be similar to the response to the original traumatic events. In the case of complex trauma, there may not be any recall of past traumatic events that triggers the present-day response.

It is possible to modify emotional memories related to complex trauma during reconsolidation, as presented above. Recall that emotions related to complex trauma represent high entropy states in the body. The approach is very similar to what I presented in the intervention for shock trauma, as briefly described below.

The Technique

As noted, I sit directly across from clients, and ask them to stay in contact with their body and with me. While aware of our connection, I ask them to look toward the left at their traumatized self (their emotional/body state) by turning only their eyes, not their head for perhaps a second, in order to activate their right hemisphere (Figure 6). By observing the emotional states of their imagined self at the left, clients effectively isolate the emotional aspect of the complex trauma. I then ask if they observe any changes in the emotional states of their imagined self. We continue the exercise until such a change occurs. At times, I may need to guide them through the process, and if I feel they need support, I might suggest they imagine I am there as a source of support. Throughout the exercise, I ask clients to avoid thinking, and to stay with their body. Once the emotional states of their imagined selves have changed, the emotional memories related to their complex trauma are erased. The new emotional body state 'z_i' that the client creates minimizes conditional mutual information related to complex trauma. The exercise usually lasts only a few minutes.

Case Study – Harry

Harry was a long-term client who had worked with me for several years. He indicated that he would become anxious in the morning, and experience contractions and tightness in his lower back. He thought this might have been related to getting ready to go to work, and dealing with his difficulties there. He was probably right! There was not a single incident that was responsible for Harry's present day reactions, but rather prolonged exposure to traumatic events in his life. This was deemed to be complex trauma. I asked Harry about his earliest memory of these reactions. Around age six, he remembered feeling similarly in the morning before going to school. He felt anxious, and remembered that he contracted his lower back, presumably to be ready for some kind of "impact."

I asked Harry to imagine himself at that age in that contracted posture and emotional state. I also asked him not to think, to remain in contact with himself and with me, and to look at his imagined self on his left (Figure 6) for one second, and to then connect with me by looking into my left eye and being aware of the space between us for two seconds. I invited him to repeat this sequence until the posture and emotional state of his imagined self had changed. He followed my instructions for a few minutes. He then reported that the posture of his imagined young self had changed. The young boy (age six) was now standing tall with his chest out, knees relaxed, and his lower back no longer contracted. At this point, his intrusive emotional memory had changed. I checked with him to make sure that the change had taken hold. During our next session, I confirmed with him that the change had been sustained. Harry reported that he was no longer anxious in the mornings, and that his lower back did not contract as much. His attitude toward his work responsibilities had also changed.

After any of these interventions, I ask clients if the new memory has taken hold. If not, then I repeat the process. I also ask in their next session if the new memory still persists, and if not, I repeat the exercise. I tell clients that after we do the technique, they should not think about the process since the new memories will be labile for about five hours (Ecker, 2015a, 2015b).

These techniques, which minimize conditional mutual information, are not unique. Based on this theory, I hope that other techniques, perhaps more efficient, can be found by other researchers.

The steps in modifying traumatic memories by erasing their emotional content can be summarized in the following steps. These bear some similarities to those described by Ecker (2015a, 2015b), but are based on the techniques described in this article.

1. Identify the past traumatic event responsible for the current symptoms.
2. Ask the client to recall (as per the above techniques) the traumatic events.
3. Create an alternative story that either contradicts or augments the traumatic memories, while subjectively minimizing conditional mutual information.

4. Check to see if the new memory has taken hold; if not, return to step 2 and repeat.

In closing, I would like to paraphrase Schrödinger's statement that life feeds on negative entropy. I have shown that if the soma feeds on negative entropy, then so should the psyche. An implication of Schrödinger's theory, as presented here, is that thriving societies also feed on negative entropy; otherwise the entropy of individual members of society will increase and lifespan will shorten. Economic systems that put profit ahead of human needs increase social and environmental entropy, as do wars, overpopulation, and pollution. Human activity in general increases planetary entropy, as promised by the second law of thermodynamics, but reckless human behavior resulting in global warming substantially increases the planet's entropy, and consequently increases social entropy and therefore entropy within living organisms, including *Homo sapiens*.

Conclusion

Using concepts from biology, chemistry, thermodynamics, information theory, and psychology, I have discussed how life might have formed, and how living organisms are sustained by the reduction of entropy (Schrödinger, 1967). I also showed how the thermodynamic notion of entropy within living organisms is related to the information theoretic notion of entropy within the psyche. I considered the roles of emotions and feelings in biological and psychological homeostasis. I presented a simple technique to potentially discharge excess emotional energy. On that basis, I formulated a simplified form of object relations theory and self-psychology, and presented a technique that may speed up the process of healing relational trauma. Using memory reconsolidation theory and information theoretic neuroscience, I presented two very effective techniques for modifying the emotional content of traumatic memories.

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REFERENCES

Avery, J. S. (2012). *Information theory and evolution.* World Scientific Publishing. Hackensack, NJ.

Barlow, H. (1961). Possible principles underlying the transformations of sensory messages. In W. Rosenblith (Ed.), *Sensory Communication* (1st ed., 217-234). Cambridge, MA: MIT Press.

Damasio, A. (2021). *Feeling & knowing – making minds conscious*. New York, NY: Pantheon Books.

Damasio, A. (2000). *The feeling of what happens: body and emotion in the making of consciousness*. Boston, MA: Mariner Books.

Damasio, A. (1994). *Descartes' Error*. New York, NY: Penguin Group (USA) Inc.

Castillo, L. F. D., & Vera-Cruz, P. (2011). Thermodynamic formulation of living systems and their evolution. *Journal of Modern Physics*, 02(05), 379-391.

Díaz-Mataix, L., Ruiz-Martinez, R.C., Schafe, G.E., LeDoux, J.E., & Doyère, V. (2013). Detection of a temporal error triggers reconsolidation of amygdala-dependent memories. *Current Biology*, 23(6): 467-472.

Ecker, B., Ticic, R., & Hulley, L. (2012). *Unlocking the emotional brain: eliminating symptoms at their roots using memory reconsolidation.* New York, NY: Routledge.

Ecker, B., Ticic, R., & Hulley, L. (2013b). A primer on memory reconsolidating and its psychotherapeutic use as a core process of profound change. *The Neuropsychotherapist*, 1. https://doi.org/10.12744/tnpt(1)082-099

Ecker, B. (2015b). Memory reconsolidation understood and misunderstood. *International Journal of Neuropsychotherapy*, 3(1), 2-46. https://doi.org/10.12744/ijnpt.2015.0002-0046

Erdelyi, M. H. (2006). The unified theory of repression. *Behavioral and Brain Sciences*, 29, 499-551.

Fairbairn, W. R. D. (1952). *Psychoanalytic studies of the personality*. New York, NY: Routledge.

Ferri, G., & Cimini, G. (2021). Energy in contemporary Reichian analysis. *International Body Psychotherapy Journal*, 19(2), 17-23.

Friston, K. (2009). The free energy principle: a rough guide to the brain? *Trends in Cognitive Sciences*, 13: 293-301.

Freud, S. (2012). *On narcissism: an introduction*. New York, NY: Routledge.

Freud, S. (1952). Repression. *Major works of Sigmund Freud* (pp. 59-81). London, England: Encyclopedia Britannica, Inc.

Gendlin, E. T. (1982). *Focusing.* New York, NY: Bantam.

Guntrip, H. (1973). *Personal relations therapy.* J. Hazell (Ed.). New York, NY: Jason Aronson Inc.

Hilton, R. (2007). *Relational somatic psychotherapy: Collected essays of Robert Hilton, Ph.D.* M. Sieck (Ed.). San Bernardino, CA: SBGI Press.

Homeostasis (2021). Retrieved from biologyonline.com website: https://www.biologyonline.com/dictionary/homeostasis

Homeostasis, Steady States, and Equilibria (2019). Retrieved from Rice.edu website: https://www.ruf.rice.edu/~bioslabs/studies/invertebrates/steadystate.html

Kohut, H. (1971). *The analysis of the self*. New York, NY: International Universities Press.

Lazcano, A. (2015). *Primordial Soup*. In Gargaud, M. et al. (Eds.) *Encyclopedia of Astrobiology*. New York, NY: Springer.

LeDoux, J. (1996). *The emotional brain*. New York, NY: Simon & Schuster.

LeDoux, J. (2002). *Synaptic Self*. New York, NY: Penguin Books.

LeDoux, J. (2015). *Anxious: Using the brain to understand and treat fear and anxiety*. New York, NY: Random House.

Lowen, A. (1994). *Bioenergetics: the revolutionary therapy that uses the language of the body to heal the problems of the mind*. New York, NY: Penguin/Arkana.

Mahler, M.S., Pine, F., & Bergman, A. (1975). *The psychological birth of the human infant symbiosis and individuation.* New York, NY: Basic Books.

Makin, S. (2017). Where does the brain store long-ago memories? *Scientific American*. Retrieved from Scientific American Website: https://www.scientificamerican.com/article/where-does-the-brain-store-long-ago-memories/

Oparin, A. I. (1965). *The origin of life.* New York, NY: Dover Publications.

Panksepp, J. (1998). *Affective Neuroscience*: *The Foundations of Human and Animal Emotions*. New York, NY: Oxford University Press.

Pfaff, D. (2006). *Brain arousal and information theory.* Cambridge, MA: Harvard University Press.

Pierce, J. R. (1980). *An Introduction to Information Theory: Symbols, Signals and Noise.* Mineola, NY: Dover Publications.

Reich, W. (1980). *Character analysis.* New York, NY: Farrar, Straus and Giroux.

Schrödinger, E. (1967). *What is life?* Cambridge, UK: Cambridge University Press.

Shahri, H. (2021). The Present Moment, Trauma, and Relational Somatic Psychotherapy. *International Body Psychotherapy Journal*, 20(1), 57-65.

Shahri, H. (2020). Integration of Traumatic Memories. *International Body Psychotherapy Journal*, 18(2), 106-115.

Shahri, H. (2018). Examining traumatic memories: re-encoding and reconsolidation. *The Clinical Journal of the International Institute for Bioenergetic Analysis*, (28), 45-63.

Shahri, H. (2017). Traumatic memories, a neuroscience perspective. *The Clinical Journal of the International Institute for Bioenergetic Analysis*, (27), 49-69.

Shannon, C. E. (1948). A mathematical theory of communication. *Bell System Technical Journal*, 27(3), 379-423. https://doi.org/10.1002/j.1538-7305.1948.tb01338.x

Siegel, D. J. (2015). *Brainstorm: The power and purpose of teenage brain.* New York, NY: TarcherPerigee.

Solms, M. (2021). *The hidden spring, a journey to the source of consciousness.* New York, NY: W.W. Norton.

Tirard, S. (2017). J. B. S. Haldane and the origin of life. *Journal of genetics*, 96(5), 735-739. Retrieved from: https://doi.org/10.1007/s12041-017-0831-6

van der Kolk, B. (2014). *The Body Keeps the Score: Memory, mind, and body in the healing of trauma*. New York, NY: Viking.

van der Kolk, B. (1994). *The Body Keeps the Score: Memory and the evolving psychobiology of post traumatic stress. Harvard Review of Psychiatry*, 1(5), 253-265. http://www.traumapages.com/a/vanderk4.php

Van Ness, H. C. (1969). *Understanding thermodynamics.* New York, NY: Dover Publications