Life, Entropy, Information, Emotions, and Trauma

Homayoun Shahri

Abstract

In this article, I will introduce concepts from biology, chemistry, thermodynamics, and information theory to derive a unified theory discussing how life is sustained which is argued to be based on reduction of entropy (disorder) within the living organism (Schrodinger, 1967), and will show based on information theoretic neuroscience, how the concept of entropy can be extended to the psychological system and 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, and based on their roles, I will present a technique for discharging excess energy related to emotions. I will also introduce a simplified theory of object relations and self-psychology based on the concepts discussed (reduction of entropy) and will present a technique that can speed up the treatment of relational trauma. Based on the presented theories, I will discuss the memory reconsolidation theory and show how it is possible to revise traumatic memories during the reconsolidation phase. Two techniques are then introduced based on memory reconsolidation theory and information theoretic neuroscience which are highly effective in potentially erasing the emotional content of traumatic memories and the treatment of shock trauma.

Keywords: Bioenergetics, efficient coding hypothesis, entropy, free energy principle, information theory, information theoretic neuroscience, memory reconsolidation, mutual information, neuroscience, object relations, repression, thermodynamics, trauma.

Life

The planet Earth was formed about 4.5 billion years ago, and life started on Earth about 3.5 billion years in the past, and the oldest found fossilized microbes provide evidence that life on Earth might have started 3.8 billion years ago. But how did life start on our planet? This is an old question that many have attempted to answer but it seems that no fully satisfactory answer is yet provided.

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 - limited in Oxygen (Tirard, 2017). Under these conditions and in the primordial soup - oceans filled with organic molecules and powered by the sun, the authors hypothesized that the organic molecules could have gone through a series of reactions resulting in formation of more complex organic molecules and compounds. Oparin (1965) further hypothesized that the early protocells formed in a manner as described above might have been coacervates (Figure 1). In water, organic materials do not disperse uniformly, and instead lump together and may form droplets (similar to adding oil to water). If these droplets (formed in an aqueous environment) formed as colloids (a homogeneous substance consisting of large molecules) are surrounded tightly by a semipermeable boundary of water and contain complex organic compounds and molecules, then they are known as coacervates. Coacervates have the interesting property in that they allow absorption of simpler organic compounds from their environment which Oparin believed was similar to metabolism (Oparin, 1965). Oparin found that under certain conditions coacervates can be stabilized in water for weeks if they could metabolize energy. To accomplish this, Oparin added enzymes and glucose to the water. The coacervate absorbed the enzymes and glucose, and then the enzymes caused the coacervate to combine the glucose with the carbohydrates in the coacervate. This caused the coacervate to grow in size. Waste products from the reaction with the glucose were expelled out of the coacervate. Once the coacervate became large enough, it began to spontaneously break up into smaller coacervates (Oparin, 1965, p. 250-252) and the process continued. It is of interest that a structure as simple as coacervates, through absorption of matter and energy can maintain some semblance of order within its boundary. The interested reader must note that coacervates are not cells and lack 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 a simple ‘system’ capable of maintaining a certain degree of order within their boundaries. The Oparin-Haldane hypothesis has recently received renewed interest and the coacervation theory and coacervates as early protocells are topics of active research (Lazcano, 2015).

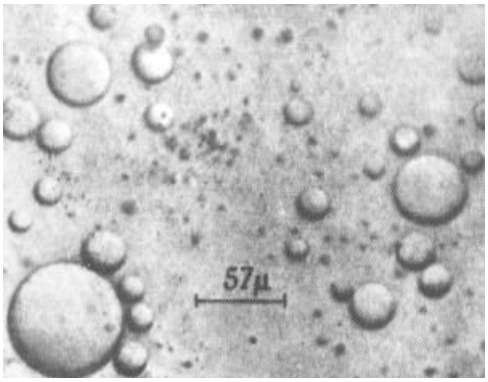

Figure 1. Coacervates (Oparin, 1965)

Systems

A system can be viewed as a group of interacting, interrelated and interdependent elements, and bounded processes. Systems transform inputs that are consumed into outputs that are produced. Systems are characterized by their boundary which separates them from their 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 functioning. A general system model is shown in Figure 2. Systems can be open or closed.

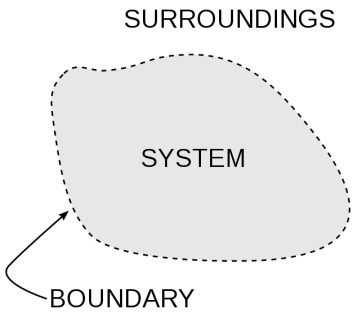

Figure 2. Basic System Model

The dynamical system concept is a formalization in which the behavior of the system is said to be 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 and surrounding. 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 an external entity or element imposing it. This structure or pattern forms from the interaction of elements that make up the system and result in self-organization.

The living organisms can be considered as dynamical systems in the most general sense of the term, and are considered subsets of all systems. Living systems are by definition

complex and self-organizing and have the special characteristics of life, and interact with their environment (open). This interaction with the environment takes place generally by means of material-energy exchanges. And these exchanges are governed by laws of thermodynamics which I will discuss next. Living systems can be as simple as a single cell or as complex as humans.

Life and entropy

The readers may skip the mathematical concepts and formulas which are included in this article for rigor, pedanticity, and completeness, which are not necessary for thorough understanding of this work. The readers may just focus on the interpretations of these concepts.

Thermodynamics is a branch in physics that explores the relationship between heat and various other forms of energy. Most of us are familiar with the first law of thermodynamics which essentially states that energy cannot be created nor destroyed (law of conservation of energy). Of interest to us in this article is the second law of thermodynamics which indicates that during energy exchanges between systems (or transfer of energy within a system) more and more energy is wasted and that systems move more and more toward disorder (higher entropy). Entropy "*S*" in thermodynamics is defined as the ratio of the energy supplied over the absolute temperature that it is supplied at (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. As an example let us suppose that 5000 Joules of energy is 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 $\Delta S_{total} = S_h + S_l = -5000/500 + 5000/200 = 15$. The '-' sign is due to negative transfer of energy from the hot reservoir, and Δ denotes difference. It can be seen that 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 $\Delta S x T_l$, which in the above example is 15x200=3000 Joules. I mentioned above that 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 to water. It is clear that molecules in water move more randomly (disorder) than molecules in ice and thus are more disordered. This process is depicted in Figure 3 below.

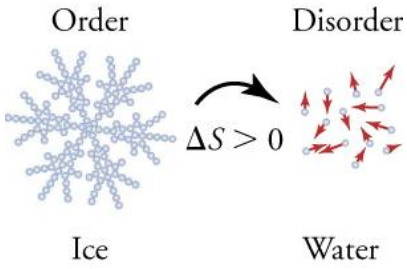

Figure 3. Increased entropy and disorder

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

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 $1.380649 \times 10^{-24} J/K$ (Joules/degrees Kelvin), and D is related to disorder of the system (Van Ness, 1969). This equation can also be written as $S = k \sum -p_i \log (p_i)$, where $\sum$ denotes sum, and p_i is the probability that the 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 ($p_i = n_i / n$). As an example, please consider the water molecules and their position and momentum within the liquid. The definitions of entropy described above are equivalent but the proof is beyond the scope of this article. For a proof see Van Ness (1969, p. 94). Of interest however are two boundary conditions, and those are the minimum and maximum entropy in systems. The entropy is zero in a crystalline, as in the crystal the particles are arranged in a fixed pattern and only one state exists which can be determined with $p_i = 1$. Note that $\log(1) = 0$ ($10^0 = 1$), and thus the sum above will be identically zero. On the other hand the entropy is at its maximum when the system approaches thermodynamic equilibrium, that is when all the energy in the system is exhausted, and the temperature in the system is uniform. The system is then left in a completely unpredictable state with the state probabilities all being equal, that is every state is equally likely resulting in maximum entropy. The above sum is maximized when all probabilities are equal. In other words the entropy reaches its maximum when the system decays and has no longer enough energy to produce work, resulting in thermodynamic death. Throughout the article the word entropy should mean disorder, chaos, uncertainty, unpredictability, and uncountability.

The Nobel prize laureate in physics, Erwin Schrodinger in his 1944 book "What is life" (Schrodinger, 1967) introduced the concept of negative entropy and declared that life feeds on negative entropy (or negentropy). I discussed above that entropy is not negative, and the second law of thermodynamics guarantees that which is to say that 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. Schrodinger 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 (Schrodinger, 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 which is not isolated, it is possible for entropy to decrease via exchange of energy and matter. This reduction of entropy within the system results in an increase of the entropy outside of the system. Life thus, according to Schrodinger, is based on reducing the entropy within the living organism. Schrodinger argued that the living organism (considered as an open, dynamical, and complex system) through exchange of energy and material, and assimilation can decrease its internal entropy. The excess entropy is discharged from the living organism through heat, work, and expulsion of waste matter after its 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 its entropy (disorder) by continuously absorbing order (negative entropy) from its environment (Schrodinger, 1967). But nothing can escape the second law of

thermodynamics, and eventually it will take over and the organism decays, reaches the thermodynamic equilibrium, and dies (see del Castillo, & Vera-Cruz, 2011). Recently there has also been renewed interest in Schrodinger's controversial theory within the field of somatic psychotherapy (Ferri & Cimini, 2021).

In biology the conditions for life described above are named the principle of biological homeostasis (2019). Homeostasis (2021) in biology is the ability of an organism to maintain internal equilibrium. It can also mean the ability of an organism to remain within an optimal range of functioning despite varying environmental changes. In this paper, I will only focus on the thermodynamic view of life for the reasons that will become apparent below. Namely, if soma thrives on feeding negative entropy (reduction of entropy within the organism), so should the psyche! From this point on in the article, and to make it more understandable, when one reads the word "entropy", one should think "disorder", "uncertainty", and "unpredictability".

Interestingly, in two recent books which have come to the present author's attention a very short while ago, Damasio (2021), and Solms (2021) also discuss the principle of homeostasis and the free energy principle, respectively. The free energy principle is closely related to the concepts that I present in this paper which are developed by the author independently of Damasio (2021) and Solms (2021). The two authors had a heated discussion about their somewhat differing ideas about consciousness in Damasio's office (Solms, 2021, p. 154). This discussion might have provided the impetus for publishing the books on the subject by the two authors.

Entropy and information

In the late 1940's Claude Shannon (1948), the creator of information theory, who was working at Bell Laboratories (where the present author also worked early in his career), was investigating the loss of information (energy) in telephone lines. He formulated and modeled the information loss and named it " the uncertainty function". Later, the mathematician John von Neumann, the father of modern computer architecture, related Shannon's uncertainty function to the thermodynamic concept of entropy and encouraged Shannon to name his uncertainty function, entropy. Shannon (1948) in his paper, 'A Mathematical Theory of Communication, published in Bell Systems Technical Journal, formally introduced the concept of information theory.

According to information theory, the information contained in the occurrence of an event 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 the event contains. For instance, the sentence, *'there is at least one rainy day in a year'*, contains very little information since the presented assertion is very likely to be valid. But the sentence, *'it will rain tomorrow'*, carries much more information as it is less likely that it will rain tomorrow than having a rainy day in a year. Another way of stating the above statements is that events that are predictable contain less information, while unpredictable events contain more information. The interested reader should already see the connection between Shannon entropy and thermodynamic entropy.

Shannon (1948), quantified the information *'I'* contained in the occurrence of an event with probability *'p'* (a number between 0 and 1) according the following 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". Entropy measures the information content of an event *E* which 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 the uncertainty is reduced relative to occurrence of event *X* given that a related event *Y* has occurred. Or interpreted differently, *I(X;Y)* indicates how much information *Y* provides about *X* (Pierce, 1980).

$$I(X;Y) = H(X) - H(X|Y)$$

H(X|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 applied to the brain sensory information processing is that the encoding of sensory information in the brain 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." Efficient-coding hypothesis which is also known as redundancy-reducing hypothesis was introduced by 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) further writes: "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."

Horace Barlow (1961) argued that laws of nature are such that they bring order and simplicity to our complex sensory experiences (lower entropy). He further argued that the communication and coding of information in the brain should be fast, precise, and minimally redundant (efficient), and should work regardless of the interference in the communication channel. The associativity of memories can be considered as a direct corollary of Barlow's hypothesis, in that by encoding associated (correlated) information together redundancy is reduced in that memories are not encoded in separate and redundant parts. Another corollary of Barlow's hypothesis, which I will emphasize, is that when a memory is recalled, then 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 the above 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 the conditional entropy *H(X|Y)* is minimized. *H(X|Y)* is minimized when our uncertainty about the occurrence of event X is minimized given that event Y has occurred in the past. What the above statement says is that the conditional entropy *H(X|Y)* is reduced when event *X* occurring in the present bears some resemblance to event *Y* that occurred 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 starts the computation with events that have higher information content (higher entropy) that are more significant. Not only does neuroscience and information theory prove this assertion, but also it is 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 avoidance of "high entropy" and unpredictability. Thus the nervous system feeds on negative entropy in the information theoretic sense. Viewed somewhat simplistically, our brain can be thought of an information processing machine constantly trying to reduce the unpredictability of sensory input by correlating and comparing the sensory input to encoded events with high information content (entropy) that occurred in the past and finding the closest match for a response, thus increasing the mutual information and reducing redundancy in encoding of the sensory input. Pfaff (2006) relates brain arousal and emotion to information and entropy, thus indicating that emotionally significant events contain more information and are more unpredictable by their very nature.

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

Information and emotions

What are emotions? All living organisms from single cell amoeba to humans are born with innate abilities evolved to solve the basic challenges of life (lower the entropy - increase order). These challenges include: finding sources of energy; incorporating, consuming, and transforming energy and matter; maintaining a chemical balance of the interior compatible with the processes of life; maintaining organism's structure by repairing damage; defending against external threats (Damasio, 2000). Living complex systems tend to move toward homeostasis (lower entropy), that is self-regulation and stability (Avery, 2012).

At the very bottom of the evolutionary ladder in single cell organisms, one finds simple processes that promote homeostasis including approaching or withdrawing relative to an object, assimilation and discharge of waste matter. As we move up the evolutionary ladder, in multicellular organisms, we find more complicated processes that lead to homeostasis in the organism. They include (from primitive to complex) metabolic regulation, basic reflexes, immune responses, pain and pleasure behaviors, drives and motivations, emotions, and feelings (Damasio, 2000). Note that the processes that lead to biological homeostasis reduce the entropy of the organism as well. In this article I am primarily concerned with drives and motivations, emotions, and feelings.

The **drives** and motivations, at the very core, propel the organism to exchange matter and energy with the environment, assimilate, reduce the inner tension, explore the environment in order to avoid danger and overcome obstacles, and seek objects for connection and contact (in humans and mammals). Thus, the goal of drives is neither entirely satisfaction nor seeking objects, but it is to reduce the 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.” Minimization of the free energy (Solms, 2021; Friston, 2009) is equivalent to maximization of the mutual information between the sensory inputs and internal states of the organism (stimulus and response). The interested reader can thus readily see the relationship between the free energy concept and the efficient coding hypothesis (Barlow, 1961), as I have thoroughly discussed above.

In evolution, older systems never get replaced, but they are simply modified and/or augmented with new systems. At the top of the processes that promote homeostasis sit the emotions. We can 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 a higher organism to maintain its life (Damasio, 2000). In summary emotions are part of an array of biological tools that higher organisms (mammals and humans) use to regulate life. Emotions play a fundamental role in steering higher organisms toward homeostasis (Damasio, 2000). Emotions in their simplest form correspond to the energetic states of the body. They occur in the body and

are autonomic responses to external stimuli. However body states (emotions) can also be created through recall of memories which Demasio (2000) calls the “as if” loops.

In their most general form and based on the hypotheses that I have presented in this article, emotions are autonomic bodily responses to high entropy (unpredictable - novel) external stimuli (or in the surrounding environment), and as such they represent increased entropy within the unitary psychosomatic structure. Emotions are thus equivalent to entropy within the unitary psychosomatic structure. In order for the organism to return to homeostasis, excess entropy (emotions) needs to be reduced and processed. In mammals this reduction is primarily achieved through the body. Emotions (entropy) are processed and discharged predominantly by expression and taking action. The residual energy related to emotions (entropy) in mammals is typically discharged through vibration or other bodily mechanisms. Homosapiens are endowed with the ability to block the expression of their emotions to a certain extent (thus increasing entropy within the psychosomatic structure). How do these blocked emotions get released? The short answer is feelings! I will justify my answer next. Panksepp (1998), Damasio (2000, 1994), and LeDoux (2015) all agree that emotions are different from feelings and that feelings require conscious awareness while emotions occur outside of conscious control. The authors differ on the mechanisms of emotions and feelings but agree that feelings require cognitive awareness and that feelings are essentially limited to homosapiens. Feelings, during the course of evolution, resulted in enhanced emotional processing and perception within the brain of homosapiens. But I posit that feelings serve another very important purpose and that is they result in discharge of the residual emotions, when feelings accompany intention and full conscious awareness. I am not saying anything that is totally new, as the practitioners of mindfulness are aware that if one becomes 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 the feelings in processing and discharge of emotions thus becomes clear. I must however, indicate that if the emotions rise above a certain threshold (very high entropy) then the cognitive structures of the brain are not fully available for processing and discharge of emotions. The emotions, in this case, may need to be discharged through the body via expression, vibration, and other means to some extent, before one can become consciously fully aware (feel), which can then result in further discharge. An important role of the feelings is then to bring the human organism back to homeostasis through discharging the residual emotions and to lower the entropy within the human 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). I must point out that my assertion is valid for positive emotions as well as for negative emotions. I must emphasize that pain and pleasure, in their most general sense, are not emotions (LeDoux, 2015). They correspond to conditions of high entropy and low entropy within the body. When the organism cannot manage its internal entropy efficiently, entropy will increase which causes the body to react (possibly by contraction) which will in turn cause pain and discomfort. On the other hand pleasure is related to lower entropy and 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).

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

A technique

The above hypothesis lends itself immediately to a technique for discharging excess emotions (entropy). I must mention that this technique predicates on the client having the ability to sense his body, proprioception, and a strong sense of self, else this technique will not be very effective. When a client is feeling a strong emotion related to a stimulus which lingers around, I ask him to first tell me where in his body he senses the emotion. Once he can successfully identify the location of the emotion, I ask him to imagine a container that encapsulates the emotion in his body and which extends a little beyond his body so that he can observe the inside of the container in front of him. I then ask him to put his awareness on that container (feel) and not think about anything. After a few minutes, the client generally feels that the container is becoming smaller and concomitantly its content is getting smaller and more distant. I then ask the client to imagine that the container has a small covered hole (capped) in the bottom and ask him to remove the cover (cap) from the hole and let the residual energy (emotion) discharge through his legs to his toes and to the ground. This exercise usually results in successful discharge of residual emotions (entropy). I have applied this technique numerous times with success. The interested reader should recognize the similarity between this technique and a simplified version of Gendlin's focusing (Gendlin, 1982). The theory that I put forward in this article thus also proves why focusing is effective and how it works in situations where the emotions are not overwhelming.

Case study

Sue has been seeing me for about a year. She came in one day and complained about an argument that she had had with her mother and that she was just feeling "bad" and this bad feeling was lingering around and was not going away. I inquired about her sense of feeling "bad" and after a bit of analysis, it became clear to her that she was feeling a mix of anger, guilt, anxiety, as well as sadness. I asked Sue to tell me where in her body she was feeling these emotions, and she indicated that they were centered around her chest. I then asked her to imagine a container that fully encompasses these emotions and is big enough so that she could look inside and asked her to just observe the interior of the container with awareness, and not think. After a few minutes, I felt that something had shifted in her and asked her about the container and its content. She indicated that the container seemed smaller and so was the

content. I then asked her to imagine that the container is capped at the bottom, and to open the cap and let the rest of the content discharge through her body to the ground. After doing so, she felt that the “bad” feeling was gone and she was no longer carrying that emotional load with her. Once Sue was relatively free of her excess emotions related to her argument with her mother, we were able to explore her relational conflicts with her.

Relational Trauma

With the birth of an infant starts his journey of life. The first period in the life of the neonate, which is normal autism (Mahler, 1975), autoerotic phase (prior to primary narcissism) (Freud, 2012), or Schizoid stage (Lowen, 1994) starts at birth. During this stage which in terms of object relations is objectless, the infant’s drives are focused on himself (autoerotism). This period lasts about a month. At the end of this period the infant, if unscathed, has formed a relatively integrated image of his body, for example he knows that his limbs belong to him. At this point, the beginning of the second month of life, which corresponds to the symbiotic stage (Mahler, 1975), or the first half of the oral stage (Lowen, 1994), the infant faces existential anxiety and fear. In terms of object relations, this period is pre-object during which the infant's drives are mostly focused on the need satisfying part-objects (the breast, etc), and the infant experiences his mother’s functioning as part of himself (symbiotic stage). The disorders related to these periods are beyond the current scope and will not be discussed in this article.

Full object relations begin at the end of the symbiotic phase which ends around 5 months of age. The infant begins to differentiate between himself and his mother and begins to distance himself from her by pushing her away when 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 the infant fears not having the object (mother) in his vicinity and at the same time wants to differentiate from her. The drives during this and subsequent periods are focused on the object for support and safety as well as exploration of the environment. Please note that in either of these two cases, and as I discussed before, the drives serve to reduce the entropy within the infant by seeking proximity and outside of himself by exploring his environment. The needs of the infant are partially met and partially frustrated. The frustration of the infant’s needs results in higher tension (entropy) within the infant. The infant, in order to gain some control over his environment and to be able to predict it (reduce entropy), has to adapt to this situation and consequently forms neural pathways that resemble those of his mother [unsatisfying object] in order to conform to his environment and to predict it. Thus, in effect he internalizes his ‘bad’ mother in order to reduce the uncertainty (anxiety) within his environment, and in doing so his immediate needs for his 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 hand it frustrates and rejects! This is an intolerable situation and the infant, in order to control the situation, splits the internalized ‘bad’ mother into the needed or exciting object which allures but does not satisfy, and the frustrating or rejecting object. The infant will seek the exciting object (EO) throughout his life seeking a fuller human connection, thus reducing the entropy within his unitary psychosomatic structure. The ego maintains a libidinal attachment to this internalized exciting object, resulting in a split within the ego. Fairbairn (1952) calls the endopsychic structure resulting from this split, the libidinal ego. Please recall that at the end of the differentiation

subphase (Mahler, 1975) or the end of oral stage (Lowen, 1994), the infant's drives shift more toward exploration of his environment since he has developed the ability of locomotion. The child at this point moves further away from the mother and is more and more absorbed in his own activities and less aware of his mother. This period coincides with Mahler's practicing period (Mahler, 1975) or Lowen's narcissistic stage (Lowen, 1994). At this point the infant's explorative drives may face environmental negativity and rejection. That is to say his drives may be thwarted by the mother (bad object), which in turn increases the entropy in the infant by increasing his anxiety as the infant feels that his exploratory drives are blocked and that his connection with the still needed mother has weakened. In order to reduce the entropy (anxiety) the child chooses a similar strategy as before. He forms neural pathways in his brain based on his experience with his mother and in effect will block and redirect his own drives so as to conform to his environment and the limitations imposed on him by his mother (bad object). That is to say that he internalizes and identifies (identification is a stronger form of internalization) with his mother in order to reduce the uncertainty (entropy) of his environment and gain some level of control over it. This is, as I alluded to above, the rejecting and frustrating aspect of the 'bad' object (rejecting object - RO). Similar to the previous case, 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 the internal saboteur. Fairbairn contended that the good aspects of objects are not internalized, but are simply enjoyed resulting in good ego development (Guntrip, 1973). It is important to note that new neural pathways also form based on the good experiences and satisfying relationships with the good objects. These newly formed neural pathways, based on good experiences with the object, serve as ways of keeping the 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. This phenomenon is observed in therapy, as the client's brain, through his good experiences with the therapist, forms new neural pathways that are similar to those of the therapist, since we know that the brain wires through experience. These newly formed pathways support new coping mechanisms and new effective approaches to life's challenges, thus reducing entropy.

However, residuals of the original drives still remain. This is the "I" that relates to the environment and to people in the outside world. Fairbairn (1952) called this endopsychic structure, the central ego (CE). Please note that the ego forms as a result of drives going through and being shaped by the reality principle. The ego is mostly conscious but may also contain unconscious elements. Ego, albeit, in limited form, still contains some aspects of the original drives. The [central] ego is however, weak and ungrounded as some of the ego energy has been consumed, limited, and shaped by the libidinal and antilibidinal egos. Its approach to the environment and objects may be tentative and cautious. The increased entropy of the central ego experienced as possibly partial loss of the sense of self, due to its weakness and ungroundedness can be, to some extent, ameliorated by seeking mirroring self-objects, idealizing self-objects, or twinship self-objects (Kohut, 1971), where self-object is the experience of an object (person) as part of the self. This is the narcissistic line of development that self-psychology (Kohut, 1971) focuses on. Please note that the tentativeness and cautiousness of the central ego is related to perceived higher entropy and uncertainty within the individual's environment and his relative inability to approach and withdraw effectively. The individual can

reduce this entropy by finding objects that mirror him and reflect a sense of self-worth and self-value back to him (mirroring self-objects), or by finding those people who make him feel calm and comfortable (idealizing self-objects), or by finding those who give him a sense of alikeness (twinship self-objects) (Kohut, 1971).

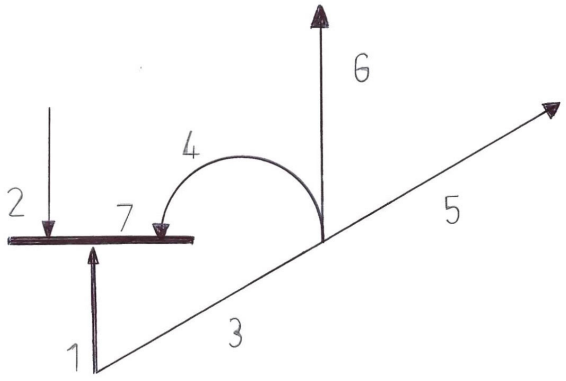

Figure 4. Relational trauma

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

The strategy that was necessary in childhood to reduce the entropy within the child's psyche acts in the opposite direction, for the most part, during adulthood. Fairbairn (1952) contended that in order for the client to risk the release of bad objects from his unconscious, he had to feel safe within the therapeutic environment and to see the therapist as the good object, so that he can become vulnerable (not function from his defenses) for his brain to form new neural pathways. He can then overcome his resistance to releasing the bad objects from his unconscious. The release of the bad object and the internalization of the good object 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 residuals always remain. Recall that Wilhelm Reich (1980) asserted that psychoanalysis is about consistent analysis of transference and resistance. Transference and resistance are nothing but the persistent activation of the old neural networks. Consistent analysis of transference and resistance is necessary for successful release and dissolution of the endopsychic structures. This is the case since formation of new neural pathways is based on the new experience with the therapist. Once the bad objects are

released from the unconscious, the conflict (high entropy) between the true self (segment 1 in figure 4) and internalized bad objects are diminished, thus reducing the entropy.

Regarding the central ego, Guntrip (1973) indicated that what needed to be strengthened was not the central ego, but the client's primary nature (related to segment 1 in Figure 4) which was repressed and arrested in development (Guntrip, 1973). 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 the bad objects is a lengthy process and takes a long time. We must analyze and work through the transference and resistance. To reiterate, while the transference and resistance are being worked through, new neural networks based on the relationship with the therapist are formed. Please recall that new neural networks are formed in the brain based on new experiences. Once the client internalizes the therapist as the good object, based on my description earlier in this article, he can risk the release of internalized bad objects. Internalization of the contact with the good object will occur over time and is a long process. Once the contact with the good object is internalized the clients do not need the presence of the therapist (good object) any longer. Although, during stressful times, contact with the good objects may be necessary for self regulation and reduction of entropy within the unitary psychosomatic structure. The interested reader should note that my description of object relations differs slightly from the way Fairbairn (1952) originally formulated it.

In order to shorten the length of the process and also for the client to experience how it feels to, albeit, temporarily let go of their internal bad objects, I designed the following technique.

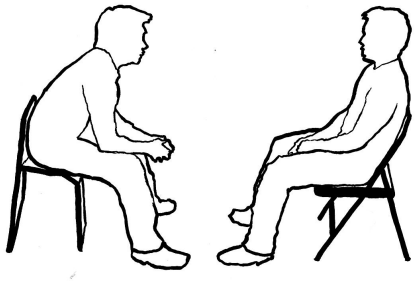

Figure 5. Working with relational trauma

The technique

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

The client must first be able to connect with his body for this exercise to be effective.

In Figure 5, I show the process of working with relational trauma. Throughout the process, I ask the client not to think. I pull my chair a bit closer to the client and ask him to stay aware of his body (from their neck down - to avoid staying in their heads) and breathe normally. I may have to coach the clients regarding staying aware of their bodies. Being aware of the body is the somatic correlate of the sense of self. Once the client is aware of his body, I then ask him to stay in contact with me. Frequently, I have to coach the client as to what staying in contact with me is. I maintain gentle eye contact with the client and look at his left eye, and I ask him to look at my left eye gently so that 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 him to be aware of the space (distance) between us (feel the connection) and I do the same (become aware of the space between him and me). Feeling and awareness of the space between him and I can be thought of as the somatic correlate of the connection. This step makes the clients aware of the presence of the good object which is felt at the somatic level. I then ask him to remain aware of his body as well as maintaining his contact with me, simultaneously. After a bit of practice, clients can follow these steps. Throughout the exercise, the client remains silent and simply stays in contact with himself and with me. I must mention that the client must have reached a certain degree of trust within the therapeutic relationship to be able to become vulnerable (drop his defenses and resistance) for this step to be effective. I also indicated above that a certain level of ego strength is needed for these exercises to be effective.

After a minute or two, or when I feel that it is appropriate to go to the next phase, I ask him to close his eyes and imagine that I am getting closer to him (as close as he is comfortable) until he experiences my energetic presence in his body and then I ask him to stay with this sensations and feelings for about a minute or two, or until I sense that he feels his contact with me in his body. I suggest that this last step is the somatic correlate of internalization. Thus through this energetic and somatic exercise, the client first connects with himself and then connects to the therapist and finally internalizes the contact. After this exercise, the clients typically feel much calmer and feel a deeper connection with me and their bodies. My clients have reported that after this exercise they can self-soothe in between sessions or when they feel emotionally overwhelmed. I must emphasize again that connecting with the self and with the good object and internalizing it is a long process. This exercise may simply shorten the process by forming a psychological imprint of these processes, through formation of new neural networks (initially weak) formed during their experience in this exercise. Future therapeutic work is then built upon strengthening these newly formed neural networks.

Case study

Nancy, a woman in her thirties, was 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 did not have a support system where she lived and felt lonely. In a session she said that even the thought of

leaving her husband would increase her anxiety dramatically. 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. In a session, about a year into her work with me, 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, and when she was ready, I asked her to open her eyes and connect with me simultaneously by looking at my left eye and 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 was comfortable, but so that she could feel my energetic presence and to stay with that. After a few minutes into the process, I asked Nancy to slowly open her eyes and stay in connection and contact with herself (feel her body). I then asked her how she felt. Her response was that she felt calm. I asked her if she still felt lonely and anxious. Her immediate response was “no”. I explained to her what this exercise was about. Nancy said in a calm tone that she wanted to feel this way “all the time”. I told her that this was our therapeutic goal but that now she knew where this place was and that her limbic system and frontal cortex have an imprint of how she felt when she was connected to herself and to me. We did this exercise several times over the course of her work. She made significant progress overtime. Nancy mentioned recently that she felt very empowered and that her anxiety was not as strong and that she felt that she had many choices and was no longer a prisoner of her fears and anxieties.

Shock trauma

When the information processing ability of the brain 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 a cohesive form, but will be, in all likelihood, fragmented with parts missing. Earlier in this paper, I discussed that due to the efficient coding hypothesis, the brain maximizes the mutual information between the stimulus and response. Please recall that mutual information is $I(X;Y) = H(X) - H(X|Y)$, and that the mutual information between X and Y is how much information Y provides about X or how much the uncertainty about X is reduced given Y has occurred. Let X be the response to a stimulus that is correlated to a traumatic event which had resulted in response Y in the past. $H(X|Y)$ is the conditional entropy of response X given the event with response Y. The mutual information is maximized when $H(X|Y)$ is minimized. $H(X|Y)$ is minimized when the response X is highly correlated to Y. In other words the efficient coding hypothesis implies that the response X to a present event will be similar to the response Y to a correlated traumatic event that has occurred in the past (repetition compulsion). We can successfully treat trauma if we are able to minimize the mutual information, in which case the 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 a novel event resulting in a different response.

In information theory conditional mutual information is defined as (Pierce, 1980) $I(X;Y|Z) = H(X|Z) - H(X|Y,Z)$. The interpretation of conditional mutual information is how much information Y provides about X given that Z has occurred, or how much Y reduces the 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. It is clear that if the occurrence of the event Z results in minimization of the conditional mutual information, then response *Y* will not lower the entropy of response *X*, and thus the individual will have an array of responses to choose from which may not be correlated to *Y*. We can make the notation more precise by writing the above equation in the following form

$$I(X|Y=y, Z=z_i) = H(X|Z=z_i) - H(X|Y=y, Z=z_l)$$

Where *'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 has occurred in the past which minimizes the conditional mutual information.

Let us consider the following example. Bob, a man in his middle age, travels to a remote island every year. He vacations there and goes fishing on occasions during his stay. He needs to know what the weather is like before he goes fishing, but there is no weather report related to this island except for a local man who can predict the weather with 90% (0.9 probability) certainty. Bob trusts this man's prediction and plans accordingly. When he goes back to the same island the following year and looks for the local weather forecaster, he is told that the man has had a stroke and is 50% (0.5 probability) cognitively impaired. Can Bob plan his fishing excursions anymore? It is easy to see that that answer is NO! Let *X* be Bob's uncertainty about the weather (clear vs stormy), and let *Y* be the local forecaster's response, and let *Z=z* be the new information which is that the local forecaster has had a stroke. It is clear that prior to the forecaster's stroke, *Y* maximized the mutual information between *X* and *Y*. $I(X;Y) = H(X) - H(X|Y)$. Note that $H(X)$ is the uncertainty about *X* (clear vs stormy). And $H(X|Y)$ is very small as Y with probability 0.9 (90%) predicts *X*. Thus the conditional entropy is close to zero which means that the mutual information is maximized. Note that if *X* has a probability of 0.5, that is Bob's prediction of the weather is similar to tossing a coin, and if the forecaster can predict the weather with a probability of 1 (100%), then *Y* provides 1 bit of information about *X* (clear vs stormy - 0 or 1 requiring only one bit), since $H(X)=1$, and $H(X|Y)=0$ (*Y* completely determines *X*). Let us now consider the added information which is that the local forecaster has had a stroke. Recall the conditional mutual information is $I(X;Y|Z=z) = H(X|Z=z) - H(X|Y,Z=z)$. Note that in this case, since the cognitive impairment of the local forecaster is 50% (probability 0.5), then $H(X|Z=z) = H(X)$. That is Bob's uncertainty regarding the weather does not change given that the local forecaster has had a stroke. On the other hand, $H(X|Y,Z=z)$ is maximized since Bob's uncertainty about the weather does not change very much, given that the forecaster has predicted the weather and given that he has had a stroke resulting in 50% cognitive decline. That is to say that his prediction is as good as tossing a coin! Therefore $H(X|Y,Z=z)$ is very close to $H(X)$. We thus see that in this case the conditional mutual information is minimized. Please also note that given the probabilities are known in this example, the mutual information and the conditional mutual information can be computed.

My interest in the nature of traumatic memories started in 2012. In particular I was interested in 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, as

to 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 results from what I call, information theoretic neuroscience, it was shown (Shahri, 2017) that the answer was that traumatic memories were neither fully repressed nor fully dissociated. When the processing of the traumatic event was beyond the information processing ability of the brain (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), in which he posited that there should exist ways to alter traumatic memories during the reconsolidation window. In 2017, while continuing my research on the subject of revising traumatic memories, 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 that was based on information theoretic neuroscience and research results from LeDoux's laboratory (Shahri, 2018). Below, I will present more advanced versions of the aforementioned technique which can erase the emotional content of traumatic memories. Independently, Ecker, Ticic, & Hulley (2012) had discussed the application of the findings from LeDoux's lab in modification of traumatic memories. I will next discuss the findings from LeDoux's lab.

Researchers in LeDoux's laboratory, Daniela Schiller, et al (2009) found that during reconsolidation, memories go through a period of instability after being recalled. The authors also introduced a behavioral technique for targeting the reconsolidation of fear memories in humans. They provided evidence that traumatic memories can be associated with benign information provided during the reconsolidation window. They showed evidence that, as a consequence of this association, fear responses to traumatic memories are no longer expressed. They indicated that this effect lasted for at least one year and affected only the reactivated relevant memories without affecting others. In a separate study in Joseph LeDoux's laboratory (Diaz-Mataix, et al, 2013), the authors indicated that while in the labile (unstable) state, which lasts about 5 hours (Ecker, 2015a, 2015b), the emotional content of traumatic memories can be modified by introduction of new information during the reconsolidation window, while leaving the autobiographical memories essentially unchanged (Ecker, 2015a, 2015b). Thus to reiterate, the research conducted in LeDoux's lab indicates that it is possible to alter emotional contents of traumatic memories by introducing additional information which contradicts or augments the original memory during the time that the memory is labile (unstable), lasting about 5 hours and before the reconsolidation phase is completed. The added information can erase the emotional content of the traumatic memory while leaving the autobiographical aspects of those memories fairly intact (Ecker, 2015a, 2015b). In order to be fully effective, the added information however, needs to minimize the conditional mutual information as I formulated above.

I would like to ask the interested reader to recall that the emotional aspects of traumatic memories are, for the most part, implicit and are encoded in the limbic system (LeDoux, 2015). The implication is that there is no direct way to directly access the [implicit] traumatic emotional memories, and thus, such memories cannot be processed by introspection. Therefore alternative interventions may be necessary to process traumatic emotional memories.

Furthermore, please note that the autobiographical aspects of the traumatic memories are formed by the hippocampus and encoded mostly in the prefrontal cortex (Makin, 2017), and amygdala attaches emotional significance (entropy) to autobiographical memories (LeDoux, 2015). The traumatic memories can go through modification when the link between the autobiographical memory and the emotional aspects of such memories is established (recall), as memories change when they are recalled (LeDoux, 2002), due to associativity. It is then that the addition of the new information can modify the aversive memories during the reconsolidation phase.

Reconsolidation occurs in everyday life. Let us consider the following example: Alice, a woman in her thirties, had a favorite restaurant where she dined once a week. A few months ago she ended up with food poisoning which she attributed to the seafood that she had at her favorite restaurant. Her symptoms started minutes after she finished her food. After her traumatic experience at the restaurant, when she drove by the restaurant or saw/smelled the same food that made her sick, she got triggered and her body reacted to her past traumatic experience. At the suggestion of her close and trusted friend, she decided to go to the same restaurant to possibly get over her aversive reactions. Upon entering the restaurant she got triggered again. Her trusted friend ordered the same food which made Alice sick and ate it 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, contradicting her original memory (expectation), was added within the reconsolidation window (her trusted friend not getting sick eating the same food), Alice's emotional aspects of her traumatic memory were erased and she was then free of her aversive traumatic reactions. Please note that if Alice had to wait for hours before knowing whether her friend ended up with the same fate as her, her traumatic memory might not have changed as this would have been outside of the reconsolidation window (5 hours).

I must now mention that the theory presented in this article fully predicts the results from LeDoux's lab. I discussed earlier that the living organism constantly must reduce and maintain its entropy to continue its existence and to reach biological homeostasis. I also discussed that in the case of homo sapiens, the psychological system must also reduce its entropy to reach the conditions of psychological homeostasis. I discussed earlier that emotions (formed spontaneously in response to high entropy stimuli) correspond to increased entropy within the psychosomatic system. The psychosomatic system constantly strives to reduce its entropy (psychosomatic homeostasis). However, in the case of consolidated traumatic memories, due to fragmentation of memories of the traumatic events, or the high emotional charge (entropy) of the events, entropy cannot be easily reduced, in that there is high emotional charge attached to the traumatic memories. However, when a memory is recalled, during its lability, if an alternative "low entropy" (benign - predictable) story which either contradicts the original story or augments it, is introduced, the psychological system, in order to reduce its entropy, chooses it over the old highly charged (high entropy) memory and consolidates the new memory during the reconsolidation phase, leaving the original traumatic memory relatively unchanged while erasing its emotional content. That is to say, after the recall, the memories are unstable and can change and the brain chooses an alternative that has lower entropy during the reconsolidation process.

It is important to note that high entropy events require more resources to encode and consolidate, which means that traumatic memories consume more neural networks to encode and consolidate. Recall that memories are associative and can associate, if correlated, when the constituent neural networks are activated (recall has occurred). Thus when a traumatic memory is recalled and an alternative partially correlated (lower entropy) new information contradicting or augmenting it, is added, the brain associates the two stories but gives higher credence to the new (low entropy) story, and 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). The emotional content (energy) of the traumatic memory, in my experience, is usually discharged through a deep breath, soft tears, or some other somatic response.

In the following, I present two techniques for altering emotional contents of traumatic memories. The first technique is mostly applicable to the situations in which the memory of the traumatic event is relatively intact but its recall is overwhelming and triggering. In the second technique, I discuss the situations in which the memory of the traumatic event was fragmented and disjointed.

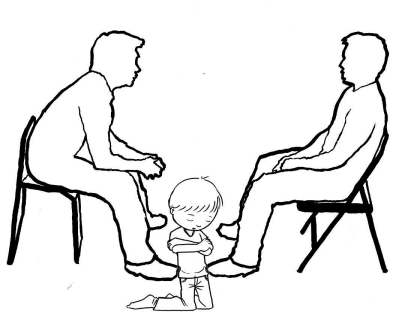

Figure 6. Working with traumatic memories - I

The technique - I

I sit directly across from the client and ask him to bring the traumatic memory to his attention (recall) as if he is watching someone else going through the trauma, and he (client) is safe with me, so that he does not get overwhelmed or activated. I then ask him to stay in contact with his body and with me similar to the way I described earlier, and while aware of our connection, to look at himself (his emotional states) on his left (by just moving his eyes and not his head) for perhaps a second (the stronger the emotions related to the intrusive memories, the shorter the duration of staying with them), to activate his right hemisphere (Figure 6). Please note that by observing the emotional states of his imagined self on the left, the client effectively decouples 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 the client to see if an alternative story contradicting the original story emerges. We continue the exercise until a more benign and empowering story has emerged. At times, I may need to guide the client through creation of the new story while they are doing the exercise or before they start. Throughout the exercise I ask the client to avoid thinking and stay

with his body. Once the new story has taken hold, the observed emotional state of his imagined self (on his left) also changes and the emotional aspect of his traumatic memory is erased. The clients always know the traumatic memories (autobiographical), but those memories no longer seem to trigger them since their emotional contents have been erased, and a more benign (low entropy) alternative story will become the dominant one in their memory. Please note that the new story 'z_i' is created by the client in such a way to minimize the conditional mutual information, and interestingly the story chosen by the client can be subjectively seen to minimize conditional mutual information, and if not, I usually make suggestions to the client and guide them to choose a different story, one that lowers the conditional mutual information. The exercise usually does not last for more than a few to several minutes. In my practice, and over the last several years, I have worked with many clients and thus far, in every case, we have been able to successfully rewrite the traumatic memories and the old intrusive traumatic memories have not returned.

Case study

Mary, a woman in her late thirties came to see me a few years ago. Her presenting issue was anxiety. She said she was also using drugs to self-medicate. Her anxiety which was to a great extent concealed manifested itself as twitches in her stomach area that were quite visible. The work with her proceeded slowly but positive transference was established fairly quickly. Six months into her therapy she mentioned that when she was a teenager, she was 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 her if she was willing to do an exercise, and she responded "yes". I asked Mary to not think throughout the exercise and feel her body and then connect with me so that she can feel both simultaneously. I then asked her to picture the incident on her left as if she was watching a movie which was somewhat foggy and unclear (to reduce her emotional arousal). I also told her to look at what was happening when she looked to the left for half a second and 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 then I noticed a change in her emotions that was apparent on her face. I asked her to stop the exercise and connect with me for a little bit which she did. I then asked her if an alternative story emerged. She said "yes" and proceeded to tell me that her parents unexpectedly showed up as the perpetrator was about to attack her. They (the parents) then called the police and the man was arrested. I asked her to look at the "incident" for just a second or so to see which was the story that came to her mind. She said, the alternative story. I told Mary not to think about the story (old or new) for a day (more than 5 hours). I checked with her again 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 the situations in which the memory of the traumatic event was fragmented and disjointed. My approach for potential rewriting of the emotional content of traumatic memories, in this case, is based on adding new information at the time of the recall of the traumatic memory to fill in the gaps within the fragmented memories (augmentation) which can then result in its re-encoding during reconsolidation. The re-encoding

of emotionally charged memories results in conversion of these aversive memories, through elaborative repression (Erdelyi, 2006) to more predictable and less emotionally charged and benign memories. The efficacy of this proposed technique is predicated on a strong therapeutic relationship which functions as a predictable holding environment and a safe container.

In order to better understand the next technique, please consider Figure 7. Pictures A and B represent two different people. Please look at A, and then B, and repeat. Since the two pictures are very different you may notice a slight activation within your nervous system (higher entropy) due to differences between the two pictures. Now please observe the sequences of pictures in the bottom of the Figure 7, one at a time and from left to right and see if the arousal compared to the previous case is reduced. The bottom figures simply morph picture A into picture B.

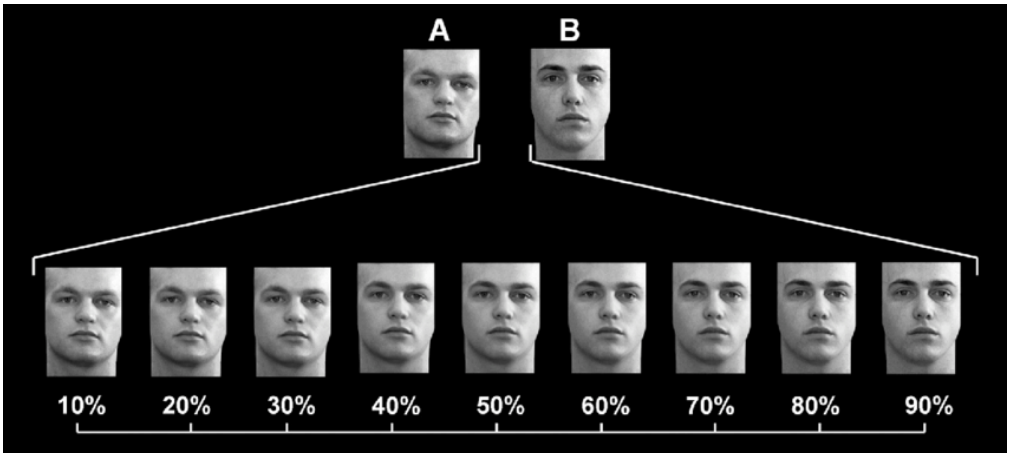

Figure 7. Filling the gaps

The technique - II

I sit across from the client (Figure 5) and ask him to recall the traumatic memory and observe himself on his left as if his imagined self is going through the fragmented traumatic event, but I ask him to recall it very slowly - one frame at a time (slow motion) and I further ask him to connect with me when he needs to, that is if the recalled material is overwhelming for him and that he needs to feel my presence and support. The recall of the traumatic memories in this way will be less overwhelming as the brain can process the high information (emotion) content of these memories and add extra information (elaborative repression - Erdelyi (2006)) to fill in the gaps, if need be, and to make sense of the traumatic memory resulting in integration. My presence with the client and his connection with me serves to reduce the arousal so that the brain can process the recalled memory and for the added information to fill in the gaps in the recalled memory. When the change has occurred, I can usually observe it on the client's face. When these early memories, which are the blueprints for many future behaviors, are re-encoded and rewritten, clients generally feel freer and do not function from their early traumas as often

and as intensely. In this technique, the conditional mutual information is minimized through filling in gaps. Even though the new story and the original story are correlated, the new story has lower entropy and augments the original story in such a way as to contradict the outcome, thus reducing the conditional mutual information. It also erases the emotional content of the original traumatic memory.

Case study

Karen, a woman in her late forties, was working with me for a number of years. Her connection with her body was not very strong and therapy with her progressed very slowly. One could say that her therapy, in general, was not very successful. In a session, she mentioned that she was very afraid of water and she would get anxious when she was even close to a swimming pool. She would also get triggered by the smell of chlorine which was usually added to swimming pools. I asked her how long she had had this symptom. She indicated that for most of her life she had been afraid of water. I further inquired as to whether she remembered anything in her childhood related to water. She remembered that when she was about five years old, she nearly drowned in a swimming pool at a resort where she and her family were vacationing. She recalled that she and a few other children were playing in the pool. An older child had pushed Karen underwater and that she could not breathe and almost drowned. Fortunately, an adult saw that she was kept underwater by the older child and came to her rescue. Her recount of this story was mostly based on what she was told by her parents, except for bits and pieces that she remembered. The whole incident had happened very fast and she could not remember very much as to what had happened. I suspected that this was the main cause of her symptoms and her fear of water. I asked Karen if she was willing to do an exercise, to which she responded “yes”. I asked her to feel her body to the extent that she could and also connect with me, as I have 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 on her left and come back to her connection with me when she needed to feel safe. But she should 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 Karen to just imagine what had happened and to just make it amusing and playful by filling in the gaps in her memory. After a few minutes, I felt that she had created an alternative story! She said that she had 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 in the next session. She indicated that her anxiety regarding water was essentially gone and she felt that she was no longer afraid of water although there were still some knee jerk reactions which did go away quickly.

Complex trauma

Complex trauma is distinguished from shock trauma in that complex trauma is characterized by the occurrence of many traumatic events and/or prolonged exposure to

traumatic stimuli. And complex trauma can be distinguished from developmental trauma, in that developmental trauma is the result of suboptimal childhood experiences during different developmental phases.

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

It is possible to modify the emotional memories related to complex trauma during reconsolidation, in a manner similar to what I have presented above. Please note that these emotions which are related to complex trauma represent high entropy states in the body. The approach is very similar to what I presented in the intervention related to shock trauma which I will briefly describe below.

The technique

I sit directly across from the client and ask him to stay in contact with his body and with me similar to the way I described earlier, and while aware of our connection, to look at his traumatized self (his emotional/body state) on his left (by just moving his eyes and not his head) for perhaps a second, to activate his right hemisphere (Figure 6). Please note that by observing the emotional states of his imagined self on the left, the client effectively isolates the emotional aspect of the complex trauma. I then ask the client to see if he observes any changes in the emotional states of his imagined self. We continue the exercise until a change in the emotional states of his imagined self occurs. At times, I may need to guide the client through the process and if I feel that they need support, I may suggest to them that they can imagine that I am there with them as a source of support. Throughout the exercise I ask the client to avoid thinking and stay with his body. Once the emotional states of his imagined self have changed, the emotional memories related to his complex trauma are erased. Please note that the new emotional body state 'z_l' is created by the client in such a way to minimize the conditional mutual information related to complex trauma. The exercise usually does not last for more than a few to several minutes.

Case study

Harry was an advanced client who had worked with me for several years. In a session, he indicated that he would get anxious in the mornings and that he would feel 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 at work. He was probably right! There was not a single incident that was responsible for Harry's present day reactions, but prolonged exposure to

traumatic events in his life. This was deemed to be complex trauma. I asked Harry when the earliest memory of his reactions was, to which he responded that he remembered around the age 6 he was feeling the same in the mornings before going to school. He felt anxious and remembered that he contracted his lower back, presumably to be ready for some kind of an "impact". I asked Harry to imagine himself at that age in that contracted posture and emotional state. I also asked him not to think, and to stay in contact with himself and with me and to look at his imagined self on his left (Figure 6) for 1 second and then connect with me by looking into my left eye and being aware of the space between us for 2 seconds, and to continue this until the posture and the emotional state of his imagined self changed. He followed my instructions and did what I asked him to do for a few minutes. He then reported that the posture of his imagined young self had changed. The young boy (6 years old) 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, and it had. I also checked with him during our next session to ascertain that the change was sustained and it was. 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, he reported.

After the exercise related to any of the interventions discussed above is done, and as I indicated in the case studies, I ask the clients about the changed memory in order to see if the new memory has taken hold. If it has not, then I repeat the process. I also ask the client in their next session to see if the new memory still persists, and again if not, I repeat the exercise. I must emphasize that I tell the clients after the techniques are applied that they should not think about the process as the new memories will be labile for about 5 hours (Ecker, 2015a, 2015b).

Furthermore the techniques, introduced above, that minimize the conditional mutual information are not unique. I do hope that other techniques, possibly more efficient, based on this theory may be found by other researchers.

We can describe the steps in modifying the traumatic memories by erasing their emotional content in the following steps. Please note that these steps bear some similarities to those described by Ecker (2015a, 2015b), but are based on the techniques that I described in this article.

1. Identify the traumatic event that is responsible for the present day symptoms.
2. Ask the client to recall (based on techniques above) the traumatic events.
3. Create an alternative story which either contradicts or augments the traumatic memories, while subjectively minimizing the conditional mutual information.
4. Check to see if the new memory has taken hold, and if not go back to step 2 and repeat.

In the end, I would like to paraphrase Schrodinger's statement that life feeds on negative entropy, and in this article I showed that if soma feeds on negative entropy, then so should the psyche. An implication of Schrodinger's theory as presented in this article is that thriving societies also feed on negative entropy, as otherwise the entropy of individual members of the society will increase and lifespan will get shorter. Economic systems that put profit ahead of

human needs increase the entropy at the societal and environmental levels, wars increase the entropy, overpopulation increases the entropy, and pollution increases the entropy. Human activity in general increases the entropy of the planet as promised by the second law of thermodynamics, but reckless human behavior resulting in global warming substantially increases the entropy of the planet and consequently increases entropy within the society and therefore within the living organisms including homo sapiens.

Conclusion

In this article, based on concepts from biology, chemistry, thermodynamics, information theory, and psychology, I discussed how life possibly formed and is maintained by reduction of entropy (Schrodinger, 1967) within the living organism. I also showed how the thermodynamic notion of entropy within the living organism is related to the information theoretic notion of entropy within the psyche. I discussed the roles of emotions and feelings in biological and psychological homeostasis. I presented a simple technique for potentially discharging excess energy related to emotions. Based on the above concepts, I formulated a simplified form of object relations theory and self-psychology, and presented a technique that may speed up the process of healing related to relational trauma. I discussed the memory reconsolidation theory. Based on the memory reconsolidation theory as well as information theoretic neuroscience, I presented two very effective techniques for modifying the emotional content of traumatic memories.

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BIOGRAPHY

Homayoun Shahri, Ph.D., M.A., CBT, LMFT, received his PhD in electrical engineering specializing in coding and information theory from Lehigh University in 1990, and his MA in clinical and somatic psychology from Santa Barbara Graduate Institute (now part of The Chicago School of Professional Psychology) in 2012. He is a licensed marriage and family therapist and has a private practice in Lake Forest, CA, USA. Homayoun is a Certified Bioenergetic Therapist and is a member of the International Institute of Bioenergetic Analysis (IIBA) and the Southern California Institute for Bioenergetic Analysis (SCIBA), and is currently a faculty-in-training at SCIBA. Homayoun is a member of the United States Association of Body Psychotherapy (USABP) and is on the peer review board of the International Body Psychotherapy Journal.

Email: homayoun.shahri@ravonkavi.com
URL: http://www.ravonkavi.com