The Breakout Heuristic: The Creative Process in Art, Science, and Therapeutic Hypnosis

Ernest Lawrence Rossi and Kathryn Lane Rossi

Abstract

Shakespeare’s *Hamlet* expresses a deep intuition about sleep, dreams, and consciousness in his famous soliloquy that begins with “To be or not to be, that is the question.” How we come to be or not to be is also the primary question of psychotherapy in general and therapeutic hypnosis in particular. Shakespeare’s prescient genius is now being confirmed by the new neuroscience of sleep and dreaming that documents how the mind and brain’s co-evolutionary process updates and actually recreates itself on a daily basis.

Even Shakespeare, however, could not have dreamed of how mind and brain actually engage in creative dialogues during sleep and dreaming that turns on gene expression, and brain plasticity to change the brain’s physical structure. This new neuroscience approach indicates that humans are not the passive automatons of the black box stimulus-response behaviorism of yesteryear. What we think, feel, and do right now at this moment, today, can actually modulate the neural networks of our brain during our sleep and dreaming tonight to change the way we experience our consciousness and free will in re-creating our behavior tomorrow. How to utilize this new perspective to create simple and more efficacious approaches to our daily work is an exciting, deeply meaningful, and truly inspiring challenge for all schools of psychotherapy and therapeutic hypnosis today.

Figure one: The four stage creative process with a student engaged in proving a mathematical theorem (With permission, Tomlin, 2005).

A Creative Dialogue Between Mind and Brain During Sleep, Dreaming and Therapeutic Hypnosis

While most psychotherapists acknowledge that their work is creative, with over 500 forms of psychotherapy and therapeutic hypnosis, there is little that is actually known about how creativity operates in what they actually do. Our current view of the classical creative process as it was first described by the prolific French mathematician, Henri Poincaré, over 100 years ago is shown in a recent comic strip where we see a student engaged in proving a mathematical theorem in figure one. The first two panels represent Stage One of the creative process where “the wheels start turning” in the mind and the student begins making diagrams and writing equations trying to solve the problem.

Stage Four is evident as he smiles with success and joyfully shouts, “Magic!” But how does this magic work? Here we present our view of a newly emerging psychosocial genomic model of how this “magic” may operate in normal everyday life and, therapeutic hypnosis as a creative dialogue with our genes.

Eric Kandel, who won the Nobel Prize in 2000 for his lifetime of research in the molecular-genomic basis of memory and learning, first described this deep psychobiological basis for psychotherapy as follows:

“... psychotherapy and counseling is effective and produces long-term changes in behavior, it presumably does so through learning, by producing changes in gene expression that alter the strength of synaptic connections and structural changes that alter the anatomical pattern of interconnections between nerve cells of the brain. As the resolution of brain imaging increases, it should eventually permit quantitative evaluation of the outcome of psychotherapy ... Stated simply, the regulation of gene expression by social factors makes all bodily functions, including all functions of the brain, susceptible to social influences. These social influences will be biologically incorporated in the altered expressions of specific genes in specific nerve cells of specific regions of the brain.

As is typical in dealing with problems in everyday life as well as therapeutic hypnosis, however, the student soon runs into difficulties – the problem is difficult – he feels “stuck” in Stage Two when his emotional conflict and despair is evident in the middle panel showing smoke arising from his activated and overheated brain. Stage Three is illustrated in the next panel as a flash of insight surrounds his head. He is so surprised by his new idea that he drops his pencil! Stage Four is evident as he smiles with success and joyfully shouts, “Magic!” But how does this magic work? Here we present our view of a newly emerging psychosocial genomic model of how this “magic” may operate in normal everyday life and, therapeutic hypnosis as a creative dialogue with our genes.
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These socially influenced alterations are transmitted culturally. They are not incorporated in the sperm and egg and therefore are not transmitted genetically."

Notice that Kandel is not talking here about classical genetics and the laws of biological inheritance where a sperm and egg get together to transmit genes from one generation to another. He is talking about "genomics." the science of how "gene expression" operates within the individual in everyday life—not the laws of inheritance between generations." Once a sperm and egg are united to create a new individual the fertilized egg undergoes a dramatic nine-month sequence of gene expression—turning genes on and off—to make the proteins that create the embryo of a new human being. At first the genes of the developing embryo are directed to turn on and off in a carefully regulated sequence by the mother's hormones. After the baby is born many genes are expressed—turned on and off—by environmental and social factors to construct and reconstruct new memory, learning and behavior. This is the new bioinformatic science we call "psychosocial and cultural genomics," which investigates how nature and nurture interact via gene expression and brain plasticity (Rossi, 2002, 2004, 2007).

It turns out that any novel, salient or surprising activity in our social and cultural environment impacts us by turning on what the biologist calls, "activity-dependent gene expression." Stressful activities and relationships can modulate activity-dependent gene expression in a manner that makes the proteins that can suppress our immune system leading to illness. This, of course, is what psychoneuroimmunology is all about. Likewise novel, positive, and interesting activities can turn on the genes that generate the proteins that facilitate what the biologists call "activity-dependent gene expression and brain plasticity"—the growth and transformation of the synaptic connections making up the neural networks of our brain, mind, and consciousness. We propose this is the psychobiological essence of what is now called Positive Psychology. This means that if you believe that you are initiating new, novel, and important activities, interpretations, and behavioral interventions in your client's life, then ipso facto you are facilitating their "activity-dependent gene expression and brain plasticity."

As with any truly new theory, however, the role of activity-dependent gene expression and brain plasticity in human experience and social affairs is still controversial. It will require decades of research to document all the genes associated with therapeutic hypnosis and psychotherapy but a beginning has already been made (Lichtenberg, 2000, 2004; Raz, 2008; Rossi, 1986/1993, 2002, 2004a&b, 2007). I am currently consulting with a research team in Italy exploring gene expression and brain plasticity during therapeutic hypnosis and psychotherapy. If we find the arc, comt, DRD4, MAOA, zif-268, and many other genes are expressed during these studies, it will be another link supporting the emerging neuroscience of psychosocial genomics and a deeper appreciation of therapeutic hypnosis as a creative human experience on all levels of mind and body. Of most direct relevance for therapy is the new research on how the mind, brain, and body are constantly engaged in dialogues on unconscious (implicit) and conscious (explicit) levels. We propose that such dialogue is an emerging model for the deep psychobiological foundation of virtually all schools of psychotherapy and therapeutic hypnosis (Rossi, 2007).

Figure two is a profile of the human brain emphasizing the hippocampus, which is the part of the brain that first records a memory of anything novel, salient or surprising. The hippocampus only makes a temporary recording of new memory, learning or behavior, however. Later, during "offline periods" of sleep, dreaming and rest when the conscious mind is not actively engaged in coping with outer realities, the hippocampus and the cortex engage in a dialogue to update, replay, and consolidate the new memory and learning in the cortex where the 'local-global computations' of consciousness occur.

Figure two: Creative Replay as the Essence of Consciousness and Psychotherapy. During "offline" periods of sleep, dreaming and rest when the conscious mind is not actively engaged in coping with outer realities, the hippocampus and the cortex engage in a dialogue to update, replay, and consolidate the new memory and learning in the cortex where the 'local-global computations' of consciousness occur: Lisman and Morris (2001) describe how this offline dialogue activates and replays novel and significant life experience between the cortex and hippocampus of the brain as follows:
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The Mind-Brain-Body Dialogues: Creative Replay as the Essence of Psychotherapy and Therapeutic Hypnosis

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Lisman and Morris (2001) describe how this offline dialogue activates and replays novel and significant life experience between the cortex and hippocampus of the brain as follows:
"... newly acquired sensory information is funneled through the cortex to the hippocampus. Surprisingly, only the hippocampus actually learns at this time — it is said to be online. Later, when the hippocampus is offline (probably during sleep), it replays stored information, transmitting it to the cortex. The cortex is considered to be a slow learner, capable of lasting memory storage only as a result of this repeated replaying of information by the hippocampus. In some views, the hippocampus is only a temporary memory store — once memory traces become stabilized in the cortex, memories can be accessed even if the hippocampus is removed. There is now direct evidence that some form of hippocampal replay occurs ... These results support the idea that the hippocampus is the fast online learner that "teaches" the slower cortex offline.

This entirely natural psychobiological "dialogue" between our cortex and hippocampus is the essential process that we attempt to facilitate in our emerging mind-body model of creative psychotherapy and therapeutic hypnosis (Rossi, Erickson-Klein, & Rossi, K., 2008-2010). From this mind-brain perspective, therapeutic suggestions, interpretations, metaphors, cognitive behavioral interventions etc. could be more aptly described as "implicit processing heuristics," which facilitate the natural dialogue between our hippocampus and the cortex. We propose that the conscious and explicit dialogues between therapist and client in psychotherapy are efficacious to the extent that they facilitate the appropriate offline, unconscious, and implicit dialogues between the cortex and hippocampus that daily update consciousness by turning on activity-dependent gene expression and brain plasticity. Implicit processing heuristics in the therapist/client dialogue are explicit hints and creative cues that we use to facilitate the offline cortex/hippocampus dialogue that evokes activity-dependent gene expression and brain plasticity for behavior change.

Why do we do this? If people have problems they are stuck somewhere in stage two of the creative process in one area or another of their lives — this is when most people tend to fall into a crisis and come to psychotherapy looking for help. The wise therapist however, knows that the "presenting problem" is usually only a ripple on the surface of the deeper waters of self-care and creative life management. Ultimately every creative individual needs to learn how to breakout of previously learned limitations on all levels from mind to gene expression and brain plasticity. Facilitating this creative process is called, "The Breakout Heuristic," in our growth oriented model of psychotherapy and therapeutic hypnosis (Rossi, 2007).

The Breakout Heuristic: Darwin’s Natural Selection of Adaptive Behavior

Recent research in evolutionary anthropology is clarifying what may have been the greatest breakout saga in human history. Our story begins in Africa when a small group of hunter-gatherers, perhaps just a few hundred, left their homes to migrate over the entire globe between 50,000 to 70,000 years ago. While the anthropology tells the outer story of the human breakout of the physical territory of Africa, psychotherapy is focused on the Inner Breakout Heuristic as we all experience it on a daily and hourly basis within the living territory of our mind-brain as the deep psychobiological basis of adaptation and behavior.

Charles Darwin, in a prescient statement on natural selection in chapter four of The Origin of Species, comments on the significance of this daily and hourly process of behavioral adaptation:

“It may be said that natural selection is daily and hourly scrutinising, throughout the world, every variation, even the slightest; rejecting that which is bad, preserving and adding up all that is good; silently and insensibly working, whenever and wherever opportunity offers, at the improvement of each organic being in relation to its organic, and inorganic, conditions of life. We see nothing of these slow changes in progress, until the hand of time has marked the long lapses of ages, and then so imperfect is our view into long past geological ages, that we only see that the forms of life are now different from what they formerly were.”

We utilize current research on Darwin’s natural selection of adaptive behavior, which distinguishes between the experience of humans and other primates at the levels of brain anatomy, neuronal activity, and gene expression. This is summarized in figure three where the large outer circle presents a new context for understanding the creative process in art, science, and psychotherapy. The outer recursive cycle of figure three outlines the evolutionary dynamics of waking, sleep, and dreaming in consolidation of new memory and learning as we breakout of old problems and re-construct our mind-brain for better adaptations in the present and future (Rossi, Erickson-Klein, & Rossi, 2008, in press. The large outer circle illustrates how (1) Novel and salient experiences while awake ranging from trauma and stress to positive creativity breakthroughs are (2) Replayed in a Natural Dialogue between the Neocortex and Hippocampus in the slow wave (SW) stages of sleep, which is followed by (3) Rapid Eye Movement (REM) Dream Sleep wherein activity-dependent genes such as ZIF-268 are turned on to generate the proteins for (4) facilitating activity-dependent Brain Plasticity that encodes the future orientation of constructive memory and behavioral adaptation.

As illustrated in figure three we facilitate the breakout heuristic in therapeutic hypnosis with (1) Implicit Processing Heuristics that (2) activate and facilitate the Natural Dialogue between the Neocortex and Hippocampus via the Review and Creative Replay that typically takes place during the novel and salient therapist/patient dialogues, which (3) tends to facilitate the creative insights that, generate the (4) the Prospective Behavioral Prescriptions that optimize problem solving and mind-body healing in psychotherapy.
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Figure Three: The Breakout Heuristic in Psychotherapy. The outer circle updates the Four-Stage Creative Process (innermost circle) at the molecular-genomic level, the Breakout Heuristic during Life Crisis (next circle) as experienced in psychotherapy, and the Monomyth Myth of the Hero (next circle) as a metaphor of the evolution of consciousness originally published 40 years ago as a metaphor and model of humanistic psychotherapy (Rossi, 2007).
The Four-Stage Creative Process in Psychotherapy and Therapeutic Hypnosis

Stage One: Initiation – Symptom Scaling, Accessing Problems & Resources
A natural introduction to activity-dependent psychotherapy begins with the typical history taking of the initial interview. More than mere words are involved. The typical tears and distress in an initial interview indicate that people are already accessing and replaying the important memories that signals they are embarking on a potentially healing adventure. The therapist’s main job here is to recognize that therapy has already begun and simply facilitate it. Basic accessing questions (Implicit Processing Heuristics) can optimize the client’s inner work even before the therapist knows all the details about the problem. The therapist may begin by the Symptom Scaling of the patient’s current emotional state. A 1 to 10 scale (10 being the worst, 5 average and zero a satisfactory state) may be used to assess and validate inner work before, during, and after every psychotherapeutic encounter.

Stage Two: Incubation – The Dark Night of the Soul. Review & Creative Replay
This is the valley of shadow and doubt, or “the storm before the light” that is portrayed in the poetry and song of many cultures. When people become stuck in stage two they become depressed. This is when they are most likely to seek psychotherapy. Emotional conflicts and symptoms that come up are actually mindbody language about unresolved problems at implicit or unconscious levels that require review, creative replay, and re-construction. The therapist’s main job is to: 1. Offer open-ended therapeutic questions (Implicit Processing Heuristics) designed to access the state-dependent memory encoding symptoms and 2. Support the signs of arousal that are typical of creativity and problem solving. Less is often more at this stage, offering respectful listening rather than giving advice.

Stage Three: Illumination – The “Aha” Experience of The Breakout Heuristic
This stage is characteristic of the famous “Aha” or “Eureka” experience celebrated in ancient and modern literature when the creative process is described in the arts and sciences. Some people smile and seem surprised when they receive an unexpected and creative thought. Many patients habitually dismiss their own originality as worthless since it has never been supported in their early life. The therapist’s main job at this stage is to help the person recognize and appreciate the value of the “new” that seems to emerge spontaneously and unheralded. Often the patient may have already thought of the possibilities and options that come up for problem solving at this stage, but dismissed them rather than testing them in reality.

Stage Four: Verification – Reality Testing and Self Prescribed Behavior Change
What changes does the client want to experience as a result of this therapy? The therapist’s job here is to: 1. Facilitate a follow-up discussion to validate the value of the psychotherapeutic process, 2. Reframe Symptoms into Signals and Psychological Problems into Inner Resources and, 3. Help the client formulate a behavioral prescription for new creative cognitions and behavior. The symptom scaling of the subject’s subjective state of being before and after the psychotherapy can be a validation of therapeutic progress, problem solving and healing.

Figure four illustrates the Four Stage Creative Process with Hand Mirroring and the types of implicit processing heuristics that therapists can utilize to facilitate the creative process (chapter nine of Rossi, 2002). While this creative process is highly structured as presented here, everyone experiences it differently. An understanding of therapeutic hypnosis and its significance is a co-creative art that engages healing dialogues between the patient and therapist rather than a standardized procedure. To evaluate the efficacy of their creative experience, clients can be asked to estimate the intensity of how much the problem (or symptom) is experienced before and after this creative process on a scale of 0% to 100%.

Stage 1: Preparation: Sensitization & Ideodynamic Experiencing.
"Place your hands up with the palms facing each other in a symmetrical manner about 6 to 8 inches apart [Therapist demonstrates]... With great sensitivity, notice what you begin to experience … Is one hand warmer or cooler than the other? …Lighter or heavier? … More or less flexible? …Stronger or weaker? A force or energy pulling them together or apart? … Do they seem to move with a mind of their own? … Allowing those hands to express whatever they need to about your feelings and life situations?

Stage 2: Incubation: Accessing, Reviewing, and Creatively Replaying Salient State-Dependent Memory, Learning, and Behavior.
"Will just one of those hands now begin to drift down slowly to signal that your inner nature will now explore some private... even secret emotions and memories...? Courage to receive all that you need to experience at this time? One part of you experiencing that as fully as you need to at this time... while another part guides you safely toward a satisfactory solution.

Stage 3: Illumination: Facilitating, Supporting and Appreciating the Creative Breakout Heuristic.
"Will the other hand now drift down slowly as you explore options and possibilities of problem-solving?... Will that hand go down slowly signaling when you are ready to begin to experience something new?... Interesting? ... Curious? ... Unexpected... Surprising. Fully appreciating the positive values of what you are receiving. Experiencing what you need for problem solving and healing? ... Exploring sources of strength and success as that hand finally comes to rest in your lap?

Stage 4: Verification: Reframe Symptoms into Signals & Problems into Resources.
When your inner mind knows you can continue these positive developments ... and when you can enjoy taking a break several times a day to review and strengthen your progress … What will it feel like to give yourself practical advice [A Behavioral Prescription] about the changes you need to make in yourself and your real life? [Review the entire session by Reframing Symptoms into Signals and Problems into Inner Resources for Self Care and life management.]
The Four-Stage Creative Process in Psychotherapy and Therapeutic Hypnosis

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Figure 4. Implicit Processing Heuristics For Facilitating The Four Stage Creative Process in Therapeutic Hypnosis with Hand Mirroring.

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“Will just one of those hands now begin to drift down slowly to signal that your inner nature will now explore some private… even secret emotions and memories…? Courage to receive all that you need to experience at this time? One part of you experiencing that as fully as you need to at this time… while another part guides you safely toward a satisfactory solution.

Stage 3: Illumination: Facilitating, Supporting and Appreciating the Creative Breakout Heuristic.

“Will the other hand now drift down slowly as you explore options and possibilities of problem-solving?… Will that hand go down slowly signaling when you are ready to begin to experience something new?… Interesting? … Curious? … Unexpected… Surprising. Fully appreciating the positive values of what you are receiving. Experiencing what you need for problem solving and healing? … Exploring sources of strength and success as that hand finally comes to rest in your lap?

Stage 4: Verification: Reframe Symptoms into Signals & Problems into Resources.

When your inner mind knows you can continue these positive developments …and when you can enjoy taking a break several times a day to review and strengthen your progress … What will it feel like to give yourself practical advice [A Behavioral Prescription] about the changes you need to make in yourself and your real life? [Review the entire session by Reframing Symptoms into Signals and Problems into Inner Resources for Self Care and life management.]
A Creative Activity-Dependent Approach to The Breakout Heuristic in Therapeutic Hypnosis

Figure five is a highly permissive and unstructured approach derived from Ericksonian therapeutic hypnosis. This approach utilizes the client’s own spontaneous ongoing behavior rather than the more highly structured approach illustrated in figure four. It requires more extensive professional training to recognize and utilize the client’s minimal mindbody language as symbolic cues and calls for the implicit processing heuristics that are now needed to facilitate the mind-brain dialogues of problem solving and healing.

“Nothing, it seems, turns on gene expression and brain plasticity as much as the presence of others of the same species!”

The therapist’s mirror neuron system needs to be empathetically alert to facilitate the constantly shifting borderline between the four stages of the creative experience (Rossi, 2007). In everyday life people rarely progress through the four stages of the creative process in the idealized order illustrated in figures four and five. Clients typically shift spontaneously between stages two and three with varying degrees of creative uncertainty, confusion, discomfort, and/or excitement. Sometimes psychosomatic symptoms are momentarily experienced more vividly. Such transitional states of the breakout heuristic can even be experienced as mini emotional crises. This is well illustrated in chapters seven and eight of The Psychobiology of Gene Expression (Rossi, 2002), which provides a verbatim transcript and psychodynamic analysis of the one-hour videotape from which figure five is drawn (“A sensitive fail-safe approach to therapeutic hypnosis” (IC-92-D-V8) is available to students and professionals from the Milton H. Erickson Foundation: Office@erickson-foundation.org; www.erickson-foundation.org.)

Figure five is an artistic sketch of how a volunteer client with rheumatoid arthritis experienced the four stage creative process of psychotherapy in front of a large professional audience of her peers. The “thought balloons” of the therapist are his conjectures of what she may be experiencing on all levels from the molecular-genomic to the cognitive-emotional-behavioral. Research is now required to assess these conjectures with the construction of standardized profiles of the four-stage creative process validated with fMRI, DNA microarrays, etc. (Rossi, 1972/2000, 2004). Note that we are calling for measurements of the ongoing creative process of psychotherapy and therapeutic hypnosis – not the measurement of fixed traits so typical of existing psychological scales and tests.

Stage One: The shy volunteer experiences an intense psychobiological arousal (evoking behavioral state-related gene expression, BSGE) associated with the novelty of experiencing psychotherapy on stage with bright lights and TV recording with a huge audience. She evidences surprise and confusion about her unusual sensations and involuntary movements that were not suggested by the therapist. The therapist wonders how to facilitate the psychosocial genomics of immunological variables such as interleukin-1, 2 and 1β associated with Cox2 that has been implicated in rheumatoid arthritis, which is her presenting symptom.

Stage Two: The client experiences the playful activity-dependent exercise of shadow boxing as a creative breakout of her typically restrained hand and finger movements associated with her rheumatoid arthritis. Future research will be needed to determine if activity-dependent gene expression (ADGE) – such as the CREB genes associated with new memory and learning – as well as the ODC and BDNF genes associated with physical growth and neurogenesis are actually being engaged during such creative moments.

Stage Three: The client experiences the typical joy of the breakout heuristic while receiving a standing ovation from the audience. The therapist speculates that the zif-268 gene may be expressed in her REM dream states tonight to encode her new and dramatic therapeutic experiences with this unusually strong show of psychosocial support. Research is now required to validate the psychosocial genomic hypothesis that such novel and salient life experiences can facilitate problem solving and healing during trauma and significant life crises on all levels from mind to gene expression and brain plasticity.
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Figure 5. An Activity-Dependent Approach to The Breakout Heuristic Via the Four Stage Creative Process in Therapeutic Hypnosis
The Psychosocial Genomics of Activity-Dependent Gene Expression and Brain Plasticity

The final image in figure five was drawn from the live action scene of the enthusiastic response of an audience of thousands of professionals who witnessed this videotaped demonstration at an Ericksonian congress of therapeutic hypnosis. Such a positive enthusiastic response requires some comment. Why do we have audiences to witness therapeutic process or, more generally, to participate in significant artistic and dramatic social events ranging from secular business and political meetings to the spiritual rituals of most cultures? It is easy enough to say that such audiences are there for education, to support a cause, etc. But what could actually be happening at a deep psychobiological level?

We offer figure six as a highly speculative interpretation that is consistent with the psychosocial genomic perspective we are presenting. Figure six is actually the results of recent bioinformatic research on fruit flies that illustrates how gene expression and brain plasticity within an individual fruit fly is related to the size of the social group it is participating in. Nothing, it seems turns on gene expression and brain plasticity as much as the presence of others of the same species!

Of course, this is documented here for fruit flies only. Yet genomic researchers consider this an example of the deeply conserved and constitutive nature of molecular-genomic experience at this deep psychobiological level of life. This means that it is likely highly that it is a life process that is common to most species – including humans.

This generalization to the human level would certainly have many interesting implications for understanding the psychosocial genomics of human behavior and society ranging from the dynamics of personal relationships to families, group processes, the madness of crowds, politics, war and peace. It could also provide us with fascinating insights into the seeming uncanny efficacy of public demonstrations of brief psychotherapy that were a frequent source of amazement discussed by therapists of the previous generation as widely diverse as Carl Rogers and Milton H. Erickson.

Summary: An Invitation to Open Source International Research

We outline a series of images from neuroscience and psychosocial genomics, which we propose as an emerging but still controversial psychological foundation for therapeutic hypnosis. While this creative approach is consistent with a great deal of current research and generations of practical clinical experience, it has not been validated to meet the criteria of evidence based medicine (EBT) and Cochran meta-analysis at this time. We therefore invite students, researchers, and clinicians to cooperate with us in evaluating these creative approaches with the combined resources and technologies of psychological scale construction to evaluate the four stage creative process with functional magnetic resonance (fMRI), DNA microarrays, and the Allen Brain Atlas of Gene Expression. Clinicians can now explore complex genomic/environmental interactions in themselves and their patients, with new personal research models available at https://www.23andme.com and many other sites on the internet.

The Breakout Heuristic: The Creative Process in Art, Science, and Therapeutic Hypnosis

Ernest Lawrence Rossi and Kathryn Lane Rossi

References


Figure 6. Preliminary evidence of an association between the size of a social group, gene expression and brain plasticity that needs to be confirmed for humans (modified from Ganguly-Fitzgerald et al., 2006).
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References
