

©1997 The Institute of Mind and Behavior, Inc.  
 The Journal of Mind and Behavior  
 Spring and Summer 1997, Volume 18, Numbers 2 and 3  
 Pages 305 [203] – 334 [232]  
 ISSN 0271-0137  
 ISBN 0-930195-08-6

## Dynamics and Psychodynamics: Process Foundations of Psychology

Hector C. Sabelli  
*Center for Creative Development*

Linnea Carlson-Sabelli  
*Rush University*

Minu Patel  
*University of Illinois at Chicago*

Arthur Sugarman  
*Center for Creative Development*

The dynamics of creative processes offers a theoretical foundation for psychodynamics, and practical methods for research and clinical practice. Psychological phenomena are complex sequences of physical action (action = energy x time). The same simple processes repeat at every level of organization: (0) spontaneous fluctuations; (1) temporal flow; (2) oppositions (harmonic, conflictual and creative) but not equilibrium; (3) co-creations of tridimensional structure, and of higher dimensional organization. Simpler processes have priority, but complex organization acquires supremacy (as contrasted to both biological reductionism and psychological autonomy). Operationalizing these principles, the process method studies processes as time series, analyzes change in terms of opposites (harmony/conflict, attraction/repulsion) using a coordinate plane, and measures organization by quantifying recurrences and entropy in multidimensional frameworks. The process method is illustrated by longitudinal recordings of mood (psychogeometry), of interpersonal relations (sociodynamic tests), and of heart rate patterns associated with emotions. These studies reveal novelty-rich multidimensional patterns (complexes), instead of the stable low-dimensional attractors of deterministic dynamics, or the random distributions of probabilistic models. Conceptualizing psychological processes as complex and creative physiological actions suggests a new approach to clinical diagnosis and treatment.

---

This research was supported by private grants from Mrs. Marjorie Trobaugh, and from Mrs. Maria McCormick to the Society for the Advancement of Clinical Philosophy. We are indebted to Drs. C. Webber and J. Zbilut for use of their programs to measure and plot recurrences; to Ms. Renée Luecht, Karen Walthall, and Cynthia Tom Klebba for technical assistance; and to David Afton, Barry Grushkin, Louis Kauffman, and Jerry Konecki for meaningful discussions. Requests for reprints should be sent to Hector C. Sabelli, M.D., Ph.D., Center for Creative Development, 2400 N. Lake View Avenue, Chicago, Illinois 60614, or e-mail to [hsabelli@rpslmc.edu](mailto:hsabelli@rpslmc.edu).

In this paper we present a general theory of creative processes as a foundation for psychological science and clinical practice. Process theory integrates dynamics and psychodynamics within the framework of the theory of flux advanced by Heraclitus, the ancient Greek physiologist who introduced both "psyche" and "logos" as scientific terms. For centuries overshadowed by mechanics and by logic, the process paradigm re-emerged with nineteenth century evolutionism and dialectics. In a Heraclitean spirit, James spoke of the "stream of consciousness," Freud developed psychodynamics based on hydrodynamic and thermodynamic models, Jung highlighted the union of opposites, and Moreno viewed life and therapy as a co-creation founded on spontaneous change. More recently, the bridging of the body-mind gap by biological psychiatry represents the most important philosophical discovery of the century. The emerging sciences of processes (nonlinear dynamics, fractal geometry, and far-from equilibrium thermodynamics) provide methods to study complex psychological processes. Process theory formulates the process approach as an equation (Kauffman and Sabelli, 1997) and as a set of hypotheses. These principles provide the rudiments of a foundation for psychology (Sabelli, 1989; Sabelli and Carlson-Sabelli, 1989, 1996a, 1996b), as well as clinical formulations and psychotherapeutic techniques (Carlson-Sabelli and Sabelli, 1984, 1992a, 1992c; Carlson-Sabelli, Sabelli, and Hale, 1994; Carlson-Sabelli, Sabelli, Hein, and Javaid, 1990; Carlson-Sabelli, Sabelli, Patel, and Holm, 1992; Raaz, Carlson-Sabelli, and Sabelli 1992; Sabelli and Carlson-Sabelli, 1991; Sabelli, Carlson-Sabelli, and Javaid, 1990; Sabelli, Carlson-Sabelli, and Messer, 1994). Here we stress methodological applications, because theory should be valued by its scientific productivity. We ask your forgiveness for the density of the information presented in an effort to unify a vast field. We hope that this summary of progress up to date serves to whet your appetite, and provides guidance to references often outside the psychological literature.

In psychology, as in other sciences, hypotheses and measurements start with the definition of dimensions, beginning with time and energy. Reducing complex psychological processes to their physical components is validated by fruitful results as well as by scientific parsimony. However, standard physics does not concern itself with communication and with organization, two fundamental features of biological and psychological processes. Instead of reducing psychology to physics, one may expand physics to include complex processes. Information is defined and measured by communication theory (Shannon and Weaver, 1949). Organization can be measured by nonlinear dynamics.

## Psychological Processes are Physical Actions

### *Process Principle*

Everything is a process, a sequence of directed actions, an energy flow.

*Monism.* Biological and mental processes are made of the same stuff, physical energy. Matter is made of energy; information requires an energetic or material carrier. Psychological energy is epitomized by attention. Energy is conserved (first law of thermodynamics), hence dualism cannot explain how a non-physical soul could affect brain function. Dualism lingers not only in religious spiritualism but also in the artificial distinction between biological and psychological dysfunctions, and in the artificial split of economic motivation, neglected by psychodynamics, from psychological motivation, reduced to rational choice by standard economic theory, but fully acknowledged in economic practice, such as advertising.

*Action = energy x time.* Change is never interrupted. Mechanical movement does not require energetic input as demonstrated by inertia. Gasses spontaneously expand, and so does the universe. Likewise the stream of consciousness never stops. Psychological processes are flows of physical energy in a complex brain. Energy is not only conserved but also flows constantly. The flow of energy is action, defined in physics as energy multiplied by time (Figure 1B). Physical quanta have the dimensions of action (Planck's constant). At all levels of organization, entities are actions; for example, "attraction," "re-action," action potentials, and "e-motions." Energy is not an independent dimension, because it never occurs except as change in time. One must expand Freud's concept of psychological energy (libido) to include time and flow. Exalted psychological energy manifests as creative flow in artists and scientists (Csikszentmihalyi, 1990).

*Health as action, not equilibrium.* High energy results in high spontaneity, and high creativity, the hallmarks of psychological health. Yet the notion that processes tend to static equilibrium dominates thermodynamics and psychodynamics, as illustrated by the concepts of mental equilibrium and family homeostasis that permeate psychoanalysis, behaviorism and family therapy. Goldstein (1995) has convincingly argued for the need to expand psychological theory beyond this equilibrium model. In fact biological equilibrium is reached only with death, and physical equilibrium never exists. As theory is action, the choice of creative process or of static models is a significant decision regarding personal and social health.

*Quantity.* Action is a quantity. There are units of action at every level of organization (physical quanta, days, action potentials, action patterns, life span), so processes can be measured in relevant action units.

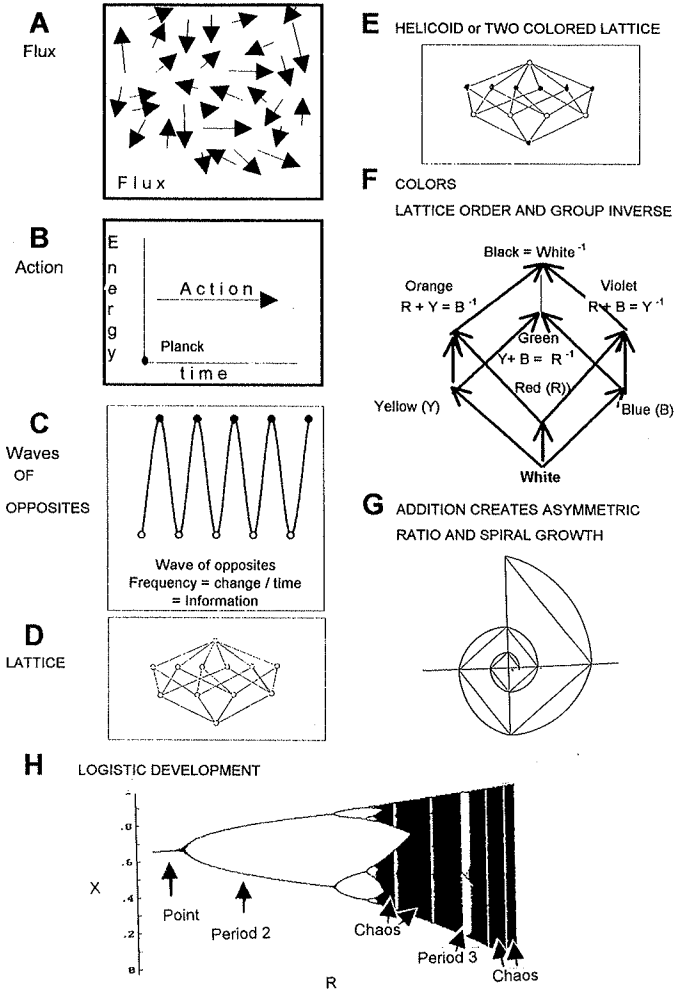


Figure 1: Cosmic forms: (A) Flux, as in Brownian movement, white noise, and deterministic chaos. (B) Asymmetric flow of energy. (C) Waves as alternation of opposites. (D) Lattice: hierarchical structure created by sequences of asymmetric actions. (E) Two-colored lattice (helicoid), modeling both temporal order and the alternation of opposites. (F) Color lattice-group: trifurcation into three complementary classes creates a set of opposites (secondary colors). (G) Spiral growth or convergence to point attractor, as modeled by the Fibonacci series. (H) Logistic development, illustrating differentiation created by growth and opposition. The logistic equation  $x_{n+1} = Rx_n(1 - x_n)$  models growth by iteration (here 1000 iterations starting with  $x_0 = 0.001$ ) and feedback opposition (factor R). The results are plotted as a function of R, and illustrate a cascade of bifurcations (4, 8, 16 . . . ), chaos, and various periodicities (3, 5, 7 . . . ). Sarkovskii's theorem demonstrates that period 3 implies chaos and all other possible periodicities. The fold catastrophe, the simplest form of bifurcation, is depicted in Figure 3D.

*Conservation and change.* Processes conserve energy–matter, and change form. Physical and personal identity is a continuity that includes both being and becoming. Insofar as energy is conserved, attention and emotional investment have the hydrodynamic properties postulated by Freud. Attention is the “currency” of personal and interpersonal life. Yet, as organisms exchange energy with the environment, psychological energy can increase or decrease. In our view mania and depression are characterized by the overall increase and decrease in psychological energy, which accounts for the symptomatology (e.g., increased spontaneity, action, attention, opposition, bifurcation, chaos and creativity in mania [Sabelli et al., 1990]).

*Asymmetry.* Energy flows in one direction, time: this is the fundamental postulate that process theory adds to mechanics. Pasteur postulated that asymmetry is a universal feature of all processes, a view confirmed by physics and biology (Clynes, 1969; Haldane, 1960) and applicable to psychological processes and structures (Corballis and Beale, 1976; Sabelli, 1989).

Action is transitive: interaction causes change. We propose that the asymmetry of action is the fundamental order that accounts for *causality* and evolution. We view structural asymmetries as the imprint of the actions that created them.

### *Methodology*

The concept of action underlies action therapies (Carlson–Sabelli, Sabelli, and Hale, 1994), and also guides scientific methodology. (1) Focus on change, not on state or structure. Processes cannot be portrayed by single observations, no matter how exact, objective, and reliable; *time series* generated by longitudinal recordings are required. (2) Identify units of action at the relevant level of organization, and quantify the process in terms of their frequency. (3) Study the various aspects of a process, rejecting disciplinary barriers as distorting abstractions.

### *Experimental*

Illustrating these strategies, we obtain 24 hour electrocardiographic recordings, and measure the interval between cardiac contractions (units of action) as an indicator of emotional behavior, and to study psychiatric illness (*electropsychocardiography* [Carlson–Sabelli et al., 1996; Carlson–Sabelli, Sabelli, Zbilut et al. 1994; Sabelli et al., 1994; Sabelli, Carlson–Sabelli, Patel, Levy, and Diez–Martin, 1995; Sabelli, Carlson–Sabelli, Patel, Zbilut et al., 1995; Sabelli, Patel, Carlson–Sabelli, Sugerman, and Messer, 1995]). Compared to random series with the same statistical variability (as can be created by shuf-

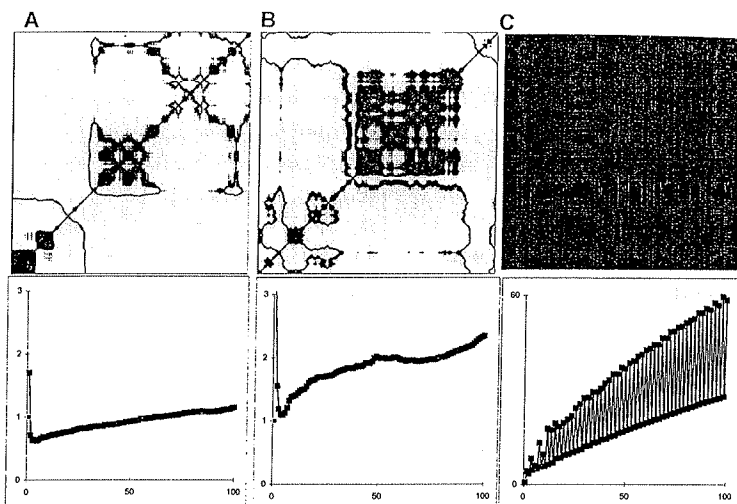


Figure 2: Electropsychocardiography: Recurrence analysis of cardiac beat to beat intervals recorded during sleep from a normal person (A) and a psychotic (B) patient. For comparison, (C) recurrence plot of a chaotic series created with the logistic equation ( $x_{n+1} = R x_n (1 - x_n)$ ;  $R = 3.6$ ;  $x_n = 0.001$ ). Top: recurrence plots of 480 intervals constructed with 50 embeddings. Bottom: embedding plots of 3500 data points showing percent of recurrences (y axis) as a function of the number of embedding dimensions used to determine recurrences (x axis). Note the different scale required for the chaotic pattern.

fling the data), ordered series, periodic or chaotic, have high recurrence rate. Recurrence rate is lower for cardiac beat intervals, suggesting that psychobiological organization creates novelty beyond that generated by chance. Organization and ordering thus appear to be opposite departures from randomness. Both are patterns; thus sequences of consecutive recurrences, practically absent in random data, are frequent in cardiac beat interval series and in periodic or chaotic ordered series. The rate of consecutive recurrences are higher in patients with schizophrenic or affective psychoses than in normals (Figure 2), indicating that illness implies more patterning, rather than disordering.

### Chaos and Spontaneity in Psychological Processes

#### Process Principles

Organized processes contain, and are contained, in chaotic flux.

*Universal flux.* A flux of energy pervades space and matter. There is no rest, no zero but everywhere there is flux, chance and uncertainty. There is chaos at all levels of organization: uncertain quantum flux, molecular agitation (heat), turbulence, noise, Brownian motion, deterministic chaotic

attractors, Prigogine's creative chemical chaos, biological variability, genetic lottery, chance, and luck. Chaos means constant, complex and apparently disorganized change without a clearly directed action (Figure 1A). Deterministic chaos, a form of order with extreme sensitivity to initial conditions, amplifies fluctuations, thereby reproducing disordering microscopic flux at a macroscopic level.

*Non zero hypothesis.* Heat illustrates that flux may approach, but never attains zero. There is no absolute  $0^{\circ}$  temperature (Nernst theorem, also known as the third law of thermodynamics). There is no absolute vacuum; space is full of energy ( $3^{\circ}\text{K}$  background radiation), constantly creating pairs of opposite particles. There is no absolute rest, no complete uncertainty, no total disorder, no absolute zero. Existence and order do not oppose emptiness; rather, they oppose disordered change, noise, chance, and heat. There always is something, rather than nothing. Purported absences actually are diminished forms of their positive opposites. There is no absolute psychological or ideological neutrality or objectivity. There is no emotional emptiness, or emotional rest. There always is an "emotional *temperature*," a practical concept as illustrated by the use of warm-up techniques in action therapies. Psychological processes require moderate physical temperature ( $37^{\circ}\text{C}$ ), and cognitive processes are fostered by moderate emotional temperatures.

*Non-random flux.* Chaotic flux is disordering, but unlikely to be disordered. Highly complex processes may appear random. Random distributions are useful foils to reveal order in apparently disordered data, but total randomness and absolute equilibrium are only ideals. Normal distributions are dominated by one asymmetry, that is their central tendency. As discussed by West in this issue, human processes often create highly asymmetric, long-tailed Pareto-Zift distributions. Deterministic chaos is globally ordered. Chemical chaos forms novel dissipative structures. Personal and interpersonal chaos may contribute to create psychological structures, both normal (e.g., artistic inspiration) and pathological (e.g., delusions and obsessions in psychoses [Sabelli et al., 1990], multiple personality in dissociative disorders [Raaz et al., 1992]). Order emerges out of chaos, in Nietzsche's felicitous phrase.

### *Spontaneity*

*Chance* fluctuations contain, originate, and modify ordered flow (*cause*). Quantum flux has significant physical consequences; likewise luck is a major factor in individual life — absolute psychological determinism blames the victims of circumstances. Conversely, ordered change creates disordered flux, friction produces heat, deterministic equations generate chaotic number series, and human will produces unpredictable and often chaotic consequences. Flux not only produces *unpredictability*; more significantly, it spontaneously creates

*variability* and *novelty*. Fluctuations and chance interactions may be random and meaningless, but their consequences are determined, and can be meaningful.

*Method: Dynamic Statistics*

(1) Measure variation as the carrier of information. Do not neglect variation as random! (2) Quantify the form of each distribution (not only the extent of differences). Explore their asymmetry, rather than eliminating "outliers," or "normalizing" skewness.

*Experimental*

Average heart rate reflects both body and emotional temperature, and heart rate variability is an indicator of emotional behavior. We thus monitor pulse rate during psychotherapy to detect otherwise unexpressed emotional issues.

### **Psychological Processes as Information: The Union and Bifurcation of Opposites**

*Process Principles*

Every process contains opposites. Interactions generate change and information, not equilibrium.

*Universality and coexistence of opposites.* Matter is constituted by positive protons and negative electrons; most species have two sexes; synapses are excitatory and inhibitory; opposing emotions and opposite ideas evoke each other; danger and opportunity coexist. Persons often have opposing traits, which become manifest in different contexts; recognizing this fact has psychotherapeutic value (Levine and Leven, 1995). Opposites are distinct but united: feminine and masculine, extroversion and introversion, harmony and conflict, conscious and unconscious, intrapsychic and interpersonal, health and illness, belonging and alienation, always coexist. This is Heraclitus's union of opposites, that Hegel adopted as the dialectic principle (*contradiction*). Both traditional and mathematical logic identify rational thinking with the mutual exclusion of opposites (principle of no contradiction), but quantum mechanics demonstrates the coexistence of opposites (e.g., electron as wave and particle). Spouses often have contradictory and mutually exclusive perspectives; attention must be paid to both. Intense transferences always are both positive and negative, albeit they may appear to be one or the other, and are so named in psychoanalysis.



*Alternation.* Opposites coexist, but separately, alternating in space and time [Hegel–Engels' law of negation of the negation (Engels, 1940)]. A wave is an alternation of opposites (Figure 1C). Neither opposite has absolute primacy, but each predominates in different respects, and at different times, in alternating sequence. Processes rise and fall (period 2).

*Information as opposition.* Information is a communication between two entities, "news of a difference" (Bateson, 1979) or of a repetition, we add. Information is encoded in opposition: binary coding in computers, true and false value in logic, action or resting potential in neurons. The separation of opposites in processes (bifurcation) or in thought (distinction) creates information.

*Twoness.* Opposition and information reveal the fundamental twoness included in each unity. Action is interaction, change is exchange, information is communication. Internal and external, intrapsychic and interpersonal, opposites are both distinguishable and inseparable (as contrasted to the systems theory stress on boundaries).

*Harmony and conflict.* Opposed forces are always in part synergic and in part antagonic. Darwin, Marx, and Freud viewed opposites as coexisting in conflict, and their struggle as the motor of change. Conflict destroys more than it creates; promoting competition and struggle usually is anti-therapeutic. Systems theorists viewed complementary opposites as harmonic; applied to human relations, this view may conceal oppression and abuse. Awareness of the coexistence of harmony and conflict is useful in marital therapy.

*Similarity, difference and symmetry.* Opposites are fundamentally similar, and fundamentally different. Women and men, children and adults, compatriots and aliens, friends and foes, share generic features, and diverge in smaller specific differences. Perceiving the similarities is psychotherapeutic, promoting harmony, preventing splitting, and discrediting demonization. Changes in quantity correlate with changes in quality as illustrated by changes in time (age), size (village, town, city), or intensity (appetite and hunger). This is the law of dialectics enunciated by Engels (1940), that he attributed to Hegel. One aspect of opposition is a difference in some quantity. Thus mood and energy are low in depression and high in mania. However mixed affective disorders include both mania and depression. Opposites can increase or decrease independently, and thus have a complex relationship, not just reciprocity; for instance, anger and fear often coexist. Opposing views cannot be accommodated into a single perspective. Nonlinear dynamics allows one to understand rationally and rigorously the coexistence of opposites by separating them in two different dimensions (coordinate plane).

*Bifurcation.* An opposition represents a symmetry, but it consists of two oppositely directed asymmetric actions. Thus opposition can generate at most transient equilibrium; more often it generates cycles of alternating

dominance, and bifurcations, that is to say, change and novelty. In mechanics, opposites neutralize each other. In non-mechanical processes, opposites such as anger and fear, male and female, intuition and judgment, co-create complexity, not equilibrium. Equilibrium is forced by opposition; it is not the natural endpoint of change. Darwinian evolutionism assumed that change occurs in an incremental linear manner; this is portrayed in dynamics by gradual bifurcations. Pointing to examples ranging from freezing points to historical changes, Hegel–Engels postulated that there also are discontinuous changes in quality (dialectic leaps). The most fundamental leaps are the elementary *catastrophes* (Thom, 1975), such as the fold in the transition from one attractor to another (Figure 2D). Catastrophes offer a model for change in motivation (Guastello, 1987), perception (Steward and Peregoy, 1983), anorexia nervosa (Callahan and Sashin, 1987), bipolar mood (Sabelli et al., 1990), and dissociation (Raaz et al., 1992). But also healthy creative processes stem from the interaction of opposites. It is to create anew, not to foster equilibrium, that one must seek a balance of opposites.

### *Psychological Oppositions*

Opposite generations, sexes and classes dominate each other, albeit in a different manner. For instance, woman power (*female priority*) precedes, accompanies and succeeds *male supremacy*, as evidenced by the role of mother as the first universe, the first love, and the first identification figure, and by the longer life span of women compared to men (Sabelli, 1989; Sabelli and Carlson–Sabelli, 1995). Understanding this bidirectional dominance has psychotherapeutic implications, widely different from both patriarchalism and feminism.

*Love and self-love* are coexisting opposites, strengthening each other, a view proposed by Antonio Sabelli (as cited in H. Sabelli, 1989), and currently popular. This view contrasts with Freud's dialectics of primitive narcissism opposing, and becoming, mature love, as well as with Kohut's (1971) view of love and self-love as two separate lines of development. The union of opposites implies that both love and self-love contribute to the development of family affection, and of patriotism, and that they also are inseparable from conflict. Mother is the first identification and authority figure introjected as *super-ego* (*female priority*). Only later does the super-ego include the introjection of conflict (Freud) and love for the father, and of non-conflictual (Hartmann, 1958; Parsons, 1951) and conflictual socialization.

Freud portrayed conscious processes as logical, repressing opposite ideas and feelings to a separate realm, the irrational *unconscious*, to which he confined dialectic contradiction. However, according to the process view every thought and feeling has both a conscious and an unconscious part.

Conscious and unconscious contents are largely similar and synergistic: beliefs and feelings, racism, sexism, and depressing cognitive structures remain operative, often increased, when made conscious. We are rational, and irrational, while awake and while asleep.

Jung recognized the coexistence of opposites (*enantiodromia*) in theory, but in practice separated opposites such as extroversion and introversion as mutually opposite tendencies. On the contrary, the intensity of self-directed and other-directed action can increase together, indicating the need to use psychological scales that allow one to detect such cases. Recognizing the need to consider that opposites can coexist and increase together, Bem (1974) developed a scale to measure androgeny (masculinity and femininity), and K. Wallston, B. Wallston, Smith, and Dobbins (1987) revised the scoring of the Rotter Internal-External Locus of Control Scale to identify persons strong in both.

*Strengths and weaknesses* are inseparable. Whereas Aristotle portrayed tragedy as the contradiction between the hero's virtue and tragic flaw, the union of opposites implies drama: the protagonist's strengths and desires are also the tragic flaw. Alexander's intensity creates his empire and accelerates his death. Don Juan is killed because he is a great lover. Individual freedom both promotes and destroys families and communities. Artistic creativity is often associated with emotional lability (Andreasen, 1987), and economic hardship. Excellence implies complexity and specialization, hence vulnerability to trauma and change. Those who attempt more are more often defeated and depressed than those who moderate their expectations and efforts (Sennett and Cobb, 1973). Action increases both successes and failures, progress and decay; this same law applies to both physics and life. These concepts open a new avenue for empathic interpretation of a patient's suffering, and indicate restraint in suggesting behavioral changes.

### *Nonlinear Methodology*

Dynamics provides methods to portray complex processes as trajectories in multidimensional frameworks, such as plotting each datum against the next one (return map) or against their difference (phase plane). However dynamics does not provide criteria for the choice of axes, nor does it offer an interpretation for two-dimensional trajectories. Postulating that all processes evolve through the interaction of opposites, process theory offers both method and interpretation. (1) Find in each process its fundamental oppositions. (2) Explore the similarity of opposites and the opposition of similars, the synergy of antagonists, and the conflict of synergic actions. (3) Measure each opposite separately, and their joint variations in a coordinate plane (Figure 3). (4) Interpret return maps and phase plane trajectories as portraits of opposition.

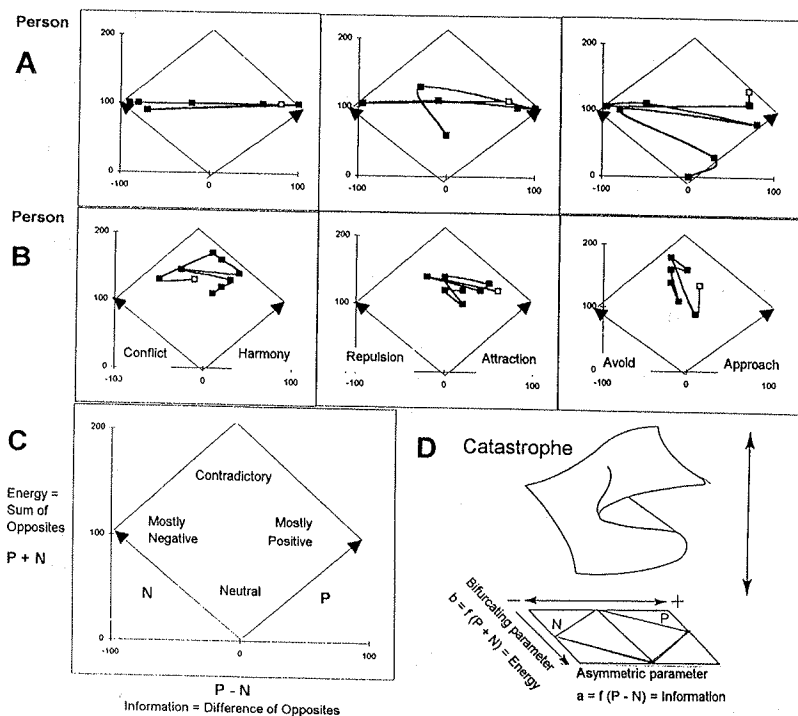


Figure 3: Plane of opposites: (A) and (B). Interpersonal diagrams: each person represents the intensity of opposite feelings regarding each of his most important relations in three planes of opposites. Dots are connected to indicate the intensity of the relations as measured by time spent together. The empty circle denotes the person with whom most time is actually spent. Note the difference between linear patterns (subject A) and bifurcating patterns (subject B) of feelings of harmony and conflict, and how these patterns are not identical with approach and avoidance behaviors. (C) The four quadrants of the plane of opposites, and their relation to the sum and the difference of opposites. (D) Sociodynamic test: plotting the positive (P) and negative (N) opposite forces of attraction (x), repulsion (y) with the behavioral outcome choice (z), generates a folded surface. It is modeled by the fold catastrophe, the simplest form of bifurcation. High attraction coupled with low repulsion predicts a choice, while low attraction coupled with high repulsion predicts a rejection; when both forces are low neutrality is predicted. When both attraction and repulsion are high, a bifurcation occurs indicated by rapid switching between choosing and rejecting when measured over time. Note the catastrophe's bifurcating and asymmetric parameters are functions of the sum and difference of opposites.

### Experimental: The Plane of Opposites

The difference between consecutive cardiac beat intervals represents acceleration, and thus depicts the opposing influences of accelerating sympathetic excitement versus parasympathetic deceleration (Carlson-Sabelli et al., 1995; Sabelli, Carlson-Sabelli, Patel, Zbilut et al., 1995).

Recording pairs of opposites such as harmony and conflict, attraction and repulsion (Figure 3) allows one to study empirically ambivalence, contradiction and ambiguity. Their importance in psychological and social processes has been widely recognized, but there have been no adequate methods to measure them. Categories force the black-or-white thinking of two-valued logic. Linear scales force us to conceive opposite drives or ideas as neutralizing each other. Both linear and categorical thinking conceal the role of ambivalence and conflict in engendering, or preventing, change. Regression analysis indicates that attraction and repulsion often are positively related (Carlson-Sabelli et al., 1992; Carlson-Sabelli, Sabelli, and Hale, 1994). Thus, to consider them as poles of a continuum is an error in measurement. In the context of both clinical psychodynamics and process theory, it is a crucial distortion of the data. The four quadrants of the plane of opposites (neutral, positive, negative and contradictory, Figure 3C) allow one to portray all cases, and transitions from one to the other. The *sociodynamic test* plots opposing motivations (attraction and repulsion, cost and benefit) for making choices in a coordinate plane, and the order of choice and rejections actually made on a third axis. When attraction (positive, P in Figure 3) and repulsion (negative, N) are both high, the coexistence of intense opposites (contradiction) manifests as ambivalence, intense irrational unilateral choices, sudden changes from one extreme to the opposite. The data fit the catastrophe model (the simplest bifurcation, Figure 3D). In this catastrophe model, the bifurcating control parameter  $b$  is the energy provided by the union of opposites:  $b = f(P + N)$ . The asymmetric factor  $a$  that provides information regarding the outcome, is given by the difference between opposites,  $a = f(P - N)$ . We speculate that this case may reflect a universal relation between energy, information and opposition (Sabelli and Carlson-Sabelli, 1992). To quantify contradiction is meaningful, because it leads to change; a person in contradiction is most vulnerable, more likely to break up a significant relation, or to change jobs, residency, or beliefs, and is more susceptible to psychotherapeutic intervention.

*Interpersonal profiles* (Figure 3). Using the plane of opposites to study opposite feelings and actions, Carlson-Sabelli and Sabelli (1992a, 1992c) found that 36% of young adults report three or more relationships in the contradictory corner of their plots; the neutral quadrant was more empty than the contradictory quadrant in all plots, indicating that coexisting opposite feelings are more likely to create ambivalent bonds than neutrality. Further, only 33% of the persons indicated a desire for purely harmonic relations! Repeated testing reveals patterns of interpersonal function. One may identify broad categories, such as harmonic, conflictual, linear, and bifurcating styles. A linear person (Figure 3A) is attracted to, and approaches the person she spends most time with, while a bifurcator (Figure 3B) places her most

significant other in the center of two of the three planes. Bifurcating personalities, characterized by multiple contradictions and frequent break-ups, are often observed in relatives of persons with bipolar (manic-depressive) illness (Sabelli et al., 1990), suggesting a genetically-determined temperament. Also artistic or scientific creativity, family conflicts, and/or socioeconomic instability can generate a history of repeated contradictions and bifurcations that may be introjected as a bifurcating life style.

### **Morphological Dimensions: Co-creation of Structure and Organization**

#### *Process Principles*

Processes create structures. Oppositions create tridimensional patterns and material structures. Triadic interactions generate all orders of periodicity and chaos. Complex interactions create novelty-generating processes of organization.

*Structure and matter.* Generating complex forms of equilibrium, opposed forces create relatively stable patterns and structures, including matter itself. Even at the subatomic level, energy is associated with particle structure.

*Co-creation.* Processes spontaneously create patterns, but "self-organization" always is an interaction. A co-creation results from the convergence of actions of disparate origin, both synergic and antagonic, an articulation that creates an opportunity. The interaction of light beams creates interference patterns and holographic images. Fields of energy likewise create material particles. Human communication creates culture and the mental constructs that make the individual's cognitive processes. The intercourse of sexes procreates new individuals. The binding of oppositely charged particles creates atoms. Intense opposite motivations (ambivalence) induce dramatic shifts in behavior, create neurotic structures, and promote creative solutions. Resistance slows down action, but it does not lead to equilibrium. Instead, opposition creates pattern and novelty. Catastrophic folds occur when opposite forces are both strong and of similar intensity. As illustrated by the simple logistic equation (Figure 1H), oppositions that limit growth generate cascades of bifurcations, and thereby create periodic and chaotic patterns, that eventually become unbound toward infinity. Each bifurcation occurs at a specific value of opposition ( $R$  in Figure 1H); changes in quantity create changes in quality. Nonlinear interactions create higher dimensions. A tridimensional catastrophe (Figure 3D) is created by the nonlinear competition between opposite point attractors. As every process includes at least two opposite components, every pattern has at least three dimensions.

*Three.* Space has three dimensions, indicating that matter involves the equilibrium between at least three forces. Processes have three aspects, energy, information, and matter. Information can be present, absent or false.

Three quarks form a proton. Mother, father and child make the nuclear family. Factor analyses indicate three dimensions of variation of normal personality (Cloninger, 1987). Processes create, conserve, and destroy structures. Not surprisingly, many models of processes are tripartite (e.g., Freud's id/ego/super-ego). Torre (1995) has convincingly shown that problem solving requires a triadic formulation. Three way splits (*trifurcation*) are creative: three attractors create chaos; period 3 implies chaos; and the human eye trifurcates light waves into three primary colors.

*Novel organization versus recurrent order.* Ordering, such as periodic repetition generates recurrences, while disordering reduces them. Bifurcations create novelty beyond the variations induced by disordering flux. Psychobiological processes (such as cardiac beat intervals) have less recurrences than random, but a high percentage of them are consecutive, denoting pattern. We thus propose to distinguish three types of processes: disordering, ordering, and creative organization.

*Diversification.* Bifurcations create diversity. Individuals become unique, as already evident in snow flakes. Novelty implies that psychological development, as biological evolution and social history, is only partially determined; diversification implies that development is a branching process, rather than a linear sequence of stages. As evolution multiplies and diversifies biological species, so individuals creatively differentiate their personalities, in healthy and pathological ways; this is in contrast to the view of pathology as the result of involution or of developmental arrest. Creative bifurcations, both psychopathogenic and psychotherapeutic, offer an alternative model to the deterministic views of many biological, psychoanalytic, behaviorist, and dialectic theories.

*Dimensiogenesis and simplification.* Differentiation of a unity into opposites adds a new quality or dimension. We conceive and measure complexity in terms of dimensions. The evolution from simple to complex is a process of dimensiogenesis. The creation of molecules, organisms, societies and psychological individuals implies informational and morphological dimensions beyond those so far described by physics. These higher dimensions of biological and psychological processes are as yet unidentified, but their number can be estimated in psychobiological data with recurrence analysis. We thus pursue the objective of defining psychological theory in terms of dimensions without reducing it to mechanics.

Simple patterns of organization such as units, oppositions and triads reoccur at complex levels of organization. In the logistic equation, repeated bifurcations create periodic and chaotic patterns: fractal complexity and periodic simplicity alternate, and create each other (Figure 1H). In the same manner, one observes in nature that increased complexity collapses into simpler forms (Cohen and Steward, 1994).

*Modules, systems, classes.* Creative processes are generic (Thomson's "principle of mass production"), producing only a limited number of types of entities at each level of organization (Mill's "principle of the uniform structure of nature"). Although individually unique, entities in the same class are exchangeable in many interactions; hence we call them "*modules*" (Carlson-Sabelli and Sabelli, 1992b; Sabelli, 1989; Sabelli and Carlson-Sabelli, 1995). Different persons may replace one another regarding social roles (parental, sexual, professional, etc.); persons often react to each other as a function of their role, as dramatically illustrated in second marriages that reproduce the problems that destroyed the first. Persons belong only transiently to any given system. Family and personal "networks" are not systems separated by boundaries, but overlapping nets of interaction centering in each person. Each person, like a sun, has a material boundary, a wider energetic field, and an even wider domain of communication. Replacing the concept of "family system" has many psychotherapeutic implications (Carlson-Sabelli and Sabelli, 1992c; Sabelli, 1989; Sabelli and Carlson-Sabelli, 1991); whereas the system theory concept of family homeostasis implies that improvement of one member be compensated by the deterioration of another, the process notion of similarity of opposites implies the probability of parallel improvement.

*Semantic structure.* Some levels of organization are alphabetical: they consist of a small number of types of units (e.g., chemical elements, DNA bases, primary colors, emotions) that combine to construct a potentially infinite number of entities (molecules, genes, colors, feelings) that constitute the next higher level of organization (Pattee, 1973). Human languages exemplify the infinite creativeness that can be so attained.

*The semantics of conditioning in the alphabet of affects.* Behavior is organized in hard-wired processes including sleep, dreaming, emotions, and other action patterns (Killeen, 1992). Affects are multiple, and enhance and inhibit each other in complex ways. Affection is *not* aim-inhibited sexuality, but a separate drive; sex and affection can be associated as in the love between spouses, but they can also contradict each other, as illustrated by the inhibition of sexuality among women and men raised together in a kibbutz.

Emotions are processes, not states, consisting of ordered sequences of actions from trigger to consummation, but they may also be interrupted by lack of external complementary response (frustration), or by the emergence of a more powerful drive. Inhibited emotions might then relax toward rest, or remain as unsatisfied drives in need of fulfillment. Just as Freud postulated that behavior tended to discharge psychological energy and to restore equilibrium, early ethologists portrayed behavioral pathways as linear sequences of appetitive behaviors from a repeller (such as hunger) to an attractor (such as satiety). This equilibrium model is misleading. First, many behavioral



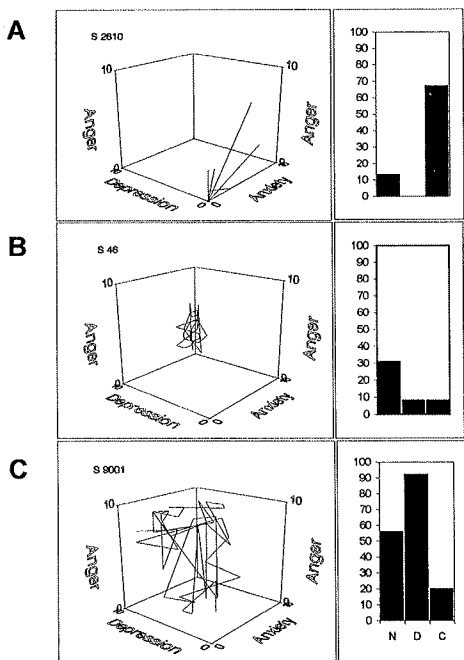


Figure 4: Psychogeometry: Daily ratings of depression, anxiety and anger (shown here for 35 consecutive days) display three types of trajectory: equilibrium (A), periodic (B), and chaotic (C). Histograms represent the percent of normal persons (N), depressed patients (D), and non-depressed criminals presenting each of these types of trajectory.

pathways, such as sleep, feeding, and sex, are cyclic (appetite–consummation–relaxation–appetite); only repellers such as pain, hunger or fear, initiate pathways toward point attractors of relief, satiety and escape. Second, consummatory acts are positive reinforcers, while frustration reduces behavior, even sustainedly (Seligman’s learned helplessness). Consummation creates appetite, as illustrated by cascades of orgasms. Contrary to the notion of cathartic discharge, emotions may actually be increased by their expression. Third, there is a profound similarity between attractors and repellers: sensations and emotions such as bitter or sweet, heat and cold, anger and fear, may be pleasurable at low intensities, and produce suffering at high intensities. This is also illustrated by appetite, that is a pleasure we seek, and hunger, that is a deprivation we avoid. A change in quantity produces a change in quality. Fourth, positive and negative reinforcers, pleasure and pain, may coexist. The mutual exclusion of opposite reinforcers postulated by conditioning theory fails to account for the pleasurable effect of righteous indignation,

theatrical tragedy, horror literature, or sexual masochism. Finally, behavior is not a self-propelling path toward an attractor, but it is co-created in interactions. External stimuli can enhance appetite, as is the case with curiosity, sex, and perhaps even violence. The market does not balance supply to demand, but it also creates demand. Appetite and consummation are interpersonal acts. Conditioning is a bidirectional relation. Emotions are interpersonal, so we share responsibility for each other's well-being, contrary to popular psychotherapeutic lore.

### *Geometric Methodology*

(1) Detect and quantify temporal patterns with methods applicable to non-stationary processes. (2) Construct spaces of three or more dimensions to study organization. (3) Identify alphabetical levels of organization.

### *Experimental*

*Psychogeometry* illustrates the use of multidimensional phase spaces to study psychological processes. Daily reports of positive and negative emotions, as well as events, are obtained for extended periods of time (Carlson-Sabelli et al., 1990; Sabelli et al., 1990; Sabelli, Carlson-Sabelli, Patel, Levy et al., 1995). Also in this case, positive (energy, joy, sexual arousal, sleep) and negative (anger, fear, depression) emotions are not inversely related. Further, opposite patterns of negative emotion, such as anger, fear and depression, are found to be positively correlated, rather than inversely related as predicted by Cannon's concept of fight or flight, and by Freud's notion of anger as depression turned in. Trajectories of anger, fear and depression reveal three types of pattern (Figure 4). (A) Equilibrium-seeking trajectories that return to emotional rest after transient changes, found in 67% of non-depressed criminals, and almost never in other populations. (B) Periodic-like patterns that were confirmed by harmonic analysis of the data. Wavelengths varied from individual to individual. Surprisingly, periodicity was also noted in the report of purportedly externally determined events! Periodic trajectories were found in 31% of normal persons, but rarely in depressed individuals. (C) Highly erratic chaotic-like trajectories that fill the state space, found in 56% of normal persons, and 87% of depressed persons. Ultradian mood variations also are increased in depressed patients (Hall, Sing, and Romanoski, 1991).

In *electrocardiographic* studies, one can study tridimensional patterns even while recording a single time series by comparing it with its time-delayed copies. In this manner Redington and Reidbord (1992) observed patterns of cardiac beat variation associated with particular psychotherapeutic stances. Higher dimensional patterns of organization can be revealed by

embedding multiple time-delayed copies, using the recurrence technique (Webber and Zbilut, 1994). Patterns of recurrences are visually different in psychotic and normal persons (Figure 2). Recurrences cluster in *complexes*, that exhibit a limited number of forms, suggesting an alphabetical level of organization. Complexes rise and fall in association with changes in behavior and emotions, as recorded diary entries made by the experimental subjects (Carlson–Sabelli et al., 1995; Carlson–Sabelli, Sabelli, Zbilut et al., 1994; Sabelli, Carlson–Sabelli, Patel, Levy et al., 1995). These data suggest that heart rate patterns reflect patterns of behavior (emotions, sleep, sex, etc.) integrated in the central nervous system. Comparison with computer-generated curves demonstrates that the timing of cardiac contractions depends more on behavioral patterns, than on intrinsic periodic or chaotic cycling. These studies lead us to model complex processes as evolving multidimensional patterns generated by interactions (complexes), in contrast to the stable low-dimensional attractors, which are overt only in the absence of interactions, postulated by deterministic dynamics. Simultaneous recordings reveal how complexes arise from personal interactions. We apply this technique in marital therapy to provide insight into how an individual's mood change may trigger conflict, but this very possibility sometimes inhibits one spouse from acquiescing to simultaneous recordings. By way of contrast, family systems theory postulates that interactions have no "punctuation," as each spouse perceives her or his behavior as a response to that of the other.

### Organization: Logos

#### *Process Principle*

Simple universal forms are the primary components of all processes, and manifest themselves in psychological archetypes and mathematical structures.

*Homology.* Evolutionary history is imprinted into anatomical structure and individual development. Thus information is conserved, in contrast to physical states that are independent from initial conditions. The metamorphosis of amphibians and butterflies reproduce the evolutionary transitions from sea to land to air. Arm, leg, fin, wing, illustrate the evolutionary concept of homology, namely a common origin that yields common features. Homology is not confined to biology: there also are profound homologies among physical and psychological processes (von Bertalanffy, 1968).

*Mathematical structures as cosmic forms and psychological archetypes.* The most dramatic example of the homology between psychological and physical processes is mathematics. Mathematics, a product of human thought, can say much about the real world, even determining with surprising accuracy interplanetary travel. Through mathematics, the human mind must undoubtedly tap into fundamental physical processes.

Pythagoras postulated that the small integers represent cosmic forms. Jung considered numbers as psychological archetypes (Robertson, 1989). Numbers represent qualities, not only quantity and order, as it is evident for small integers: 0 is the defining quality of void, and lack of order; 1 is contained in uni-directionality (time), oneness (substance), and unity; 2 is in opposition, and in information; 3 are the dimensions of space and structure. Consecutive addition ( $1+1=2$ ;  $1+2=3$  . . .) generates spiral growth, the Fibonacci series (1, 2, 3, 5, 8, 13, etc.) [Figure 1G] that describes fundamental biological forms (Cook, 1914/1979), and aesthetically pleasing asymmetric proportion. Including ever present limits to growth generates the logistic equation (May, 1976), the study of which gave its name to chaos (Yorke and Li, 1975). As the degree of opposition increases, the equation generates 1, 2, 4, 8, 16, etc. outcomes, a cascade of bifurcations that leads to chaos, which is in turn interrupted by simpler periods, odd and even, in a predetermined sequence in which period three implies all other periodicities (Sarkovskii, 1964 as cited in Devaney, 1989). As 3 and 5 are both Fibonacci and Sarkovskii numbers, it is intriguing that psychological tests reveal either three (Cloninger, 1987) or five (Costa, 1996) factors of personality.

Mathematical structures are both psychological archetypes and cosmic forms. The correspondence is not surprising, because the human brain is the best organ (insofar as we know) developed by the evolutionary processes of adaptation and selection. Thus brain processes, such as perceptions and intuitions, should be expected to provide us with a reasonably appropriate, albeit certainly not perfect, picture of the real world (Sabelli, 1989; Vandervert, 1988). We do not perceive space as tridimensional because the labyrinth has three orthogonal semicircular canals, but our ear is so constructed because space has three dimensions. We perceive time as flowing because processes are thermodynamically irreversible, and this fundamental asymmetry must be added to the basic laws of physics. Vandervert (1988) views world, brain and mind as homologous: brain, as the product of evolution, embodies its patterns, thereby being pre-adapted to portray reality. Evolution encapsulated the world as brain structure.

*Heuristic homologies.* Computer modeling has expanded the heuristic value of analogy, but, as historically determined realities, homologies offer deeper perspectives. In extending measurements of action, velocity or entropy to the biological realm, process sciences make use of probable homologies to develop a physics of life. Conversely, following Pasteur's inference of cosmic asymmetry from the asymmetry of bio-molecules, we can examine complex processes to learn from them about the simpler cosmic forms (*complexity inference* [Sabelli, 1989]).

We may thus learn about cosmic forms by examining human anatomy, with its three spatial dimensions: the unidirectionality of action in its dorso-

ventral asymmetry, opposition in its right-left (partial) symmetry, and hierarchy in its vertical dimension (Sabelli, 1989; Sabelli and Carlson-Sabelli, 1989). In fact asymmetry (Clynes, 1969; Corballis and Beale, 1976; Haldane, 1960), symmetry (Anderson and Stein, 1987), and hierarchy (Pattee, 1973) are considered cosmic forms. We view them as a "cosmic gene" that co-exists in all processes and at all levels of organization (Sabelli and Carlson-Sabelli, 1996a).

Similarly, consider the alphabet of sensations. Color (Figure 1F) illustrates the creativity of trifurcations: the physical continuum of frequencies is divided by the retinal receptors into three primary colors, and from this the mind constructs an infinite multiplicity of colors, including black, its inverse white, and secondary colors (the sum of two primaries generates the inverse of the third primary; e.g., blue + yellow = green = complementary of red). Colors thus have the properties of a group (inverses) and of a lattice (order, Figure 1D), two fundamental mathematical structures (presumably, psychological archetypes and cosmic forms). We see the *three-way split of light into primary colors as the transition from physics to biology*, and we propose that such a trifurcation reveals the cosmic form of creative processes. In this light, we consider Freud's triadic model as more revealing than self-other dichotomic schemes. The logical structure of color relations describes the types and interactions of quarks. It also fits human ideas and feelings, so colors acquire symbolic meanings (emotional, political, religious) and portray thinking styles. Neurotics (Adler), depressives (Beck, Rush, and Shaw, 1979) and fundamentalists characteristically think in black and white. Learning to think in gray is psychotherapeutic (Beck et al., 1979), but learning to think in color, that is learning to see a third alternative which does not lie between the other two, promotes creativeness (Sabelli and Carlson-Sabelli, 1996a).

*Cosmic forms.* Abstract forms such as asymmetry (Pasteur), spirality (Fibonacci, Cook) and catastrophes (Thom, 1983) are embodied in physical and in psychological processes. They are cosmic, meaning universal, order-creating, and beautifying (as in cosmetic). Process theory postulates that flux, action, opposition, and organization represent simple processes that repeat in every respect (e.g., one as oneness, asymmetry, and unity), and at every level of organization. Cosmic forms are physical processes (action, opposition, bifurcation, cycling, chaos), not static and separate from matter like Platonic ideas. Cosmic forms also manifest as void, action, information, and matter. These forms are expressed numerically as 0, 1, 2, 3. These are the dimensions of point, line, plane, and space. They correspond to randomness, lattice asymmetry, group inverse, and topological bifurcation. Lattice, group and topological theory are the three pillars of mathematics in the view of Bourbaki and of Piaget, a fact that supports their characterization as cosmic forms. These forms determine the basic psycho-social categories of generation (a temporal change), sex (an opposition), and class (a diversification).

*Topological embedding and fractal self-similarity.* Cosmic forms coexist with each other; for example, the asymmetry of action is also manifested in the asymmetry of opposites, and in each of the three dimensions of space, such as east–west rotation, north–south thermal bipolarity, and up–down in the gravitational field of the earth. Cosmic forms are nested in each other. Empty space, energy, information, and matter are inseparable components of every object. Disordered chaos, unidirectional flow, oscillation between opposites, and nucleation of tridimensional structures are coexisting and universal patterns, albeit one or another can predominate locally as an attractor. As the same cosmic forms repeat at every level of organization, processes have a fractal, self-similar structure.

*Creative processes emerge from a determined development.* Process theory postulates that cosmic forms generate evolution and are embodied in each process. Action generates both growth and interactions that facilitate or oppose growth. The logistic equation demonstrates how opposition to growth (negative feedback) generates bifurcations and chaos. The process equation  $a_{n+1} = a_n + (g (\sin a_n))$  includes both positive and negative feedback, a union of opposites (Kauffman and Sabelli, 1997). As  $g$  increases, the patterns generated by iteration go through a series of phases: static, dyadic (bifurcation), periodic, chaotic and biotic (patterns with dynamic features as observed in psychophysiological recordings such as cardiac beat intervals). The equation embodies the two postulates of process theory: (1) iteration and feedback model the dynamic identity of processes (as contrasted to the notion of identity as permanence); the sine function models the cycling of opposites. Significantly, the equation generates cosmic forms such as pi, Fibonacci and Feigenbaum's constants, and Sarkovskii's cycles. Embryological development (from one egg to 2, 4, 8, 16, etc. cells), with subsequent folding and differentiation, illustrates how cascades of bifurcations can be creative. In the same manner, other natural processes may emerge from the primary process of opposition, diverging toward individual uniqueness. Cascades of bifurcations provide a model for psychological development in which each new stage represents a differentiation into a new set of opposites, the interaction of which contributes to all subsequent processes (Sabelli, 1989; Sabelli and Carlson–Sabelli, 1989). This process model contrasts with the dialectic model advanced by Erikson, according to which each stage of development represents the resolution of a contradiction of opposites.

*Consciousness.* Cosmic forms are embedded in consciousness: (0) free associations, (1) the stream of consciousness, (2) the coexistence and bifurcation of opposites, (3) triadic organization. The coexistence of opposites manifests itself in the double nature of consciousness, which always includes both the self and the other, the mutual implication of contradictory ideas and feelings, and the coexistence of consciousness and unconsciousness. The dichotomy of

conscious and unconscious is complemented by a third, *paraconsciousness*, the distortion of conscious and unconscious processes created by conflict, such as black and white thinking, with idealization of the collective self, and demonization of the other (Sabelli, 1989; Sabelli and Carlson-Sabelli, 1989).

### *Topological Methodology*

(1) Compare data patterns with computer generated models for disordered flux (random distributions), linear flow, cycles, chaos, cascades of bifurcations. (2) Study organization in frameworks of increasing dimensions: one for linear time, a plane for information, geometric space for structure, and higher dimensional spaces to reveal higher forms.

### *Experimental*

Recurrence plots of electrocardiograms show an abundance of lattice forms (partial order, with bifurcations and unions, one origin and one end), and striking similarities between short and long patterns, suggesting a fractal structure, but one that differs from prototypic chaotic attractors in pattern (Figure 2 top), dimensions (Figure 2, bottom), and low recurrence rate (novelty). Constructing frameworks of 1 to 100 dimensions (Figure 2, bottom), we found that the number of dimensions required to account deterministically for 50% of recurrences in the electrocardiogram of normal individuals is lower for psychotic persons (Carlson-Sabelli et al., 1996; Carlson-Sabelli, Sabelli, Zbilut et al., 1994), indicating the lesser complexity of psycho-physiological patterns in these individuals. This fits clinical observations, as obsessions, compulsions, stereotypes, and lack of adaptation represent a reduced range of behavior. Psychiatric illness appears to simplify pattern and increase order.

## **Psychological Organization is Created by the Production of Entropy**

### *Process Principles*

Entropy increases with both organization and destruction. Statistical measures of entropy quantify symmetry and diversity, not disorder and uniformity.

*Health and illness, evolution and decay.* Life and death, evolution and extinction, awakening and falling asleep, illustrate that processes rise and fall; they are not stationary, nor do they tend to equilibrium, disorder, or any other stable attractor. Progress and decay overlap: neurons begin dying in infancy, and a person may grow up as she or he grows old. Either construction or

destruction may predominate, depending on multiple factors, including human choices — thus psychological life includes moral decision.

*Thermodynamics and psychodynamics.* Psychodynamics originally developed in the tension between evolutionary theory that describes progression from simplicity to complexity, and the thermodynamics of closed systems, which equates the increase in entropy with a tendency to rest and disorder. To explain this contradiction between the emergence of life and thermodynamics, both Schrödinger and Prigogine (Prigogine and Stengers, 1984) adduce that the uptake of free energy and the exportation of heat and waste can lower the internal entropy of open systems. Based on the thermodynamics of his time, Freud postulated that psychological energy tends to equilibrium. Borrowing the terminology of the physical sciences, health was equated with equilibrium, and illness with disorder. This analogy is false (Bailey, 1994): thermodynamics equates entropic equilibrium with disorder. Further, life and mind are far from equilibrium processes, open to constant exchange of energy, information and matter. Equilibrium is a rare condition, observed only transiently under artificial laboratory conditions (Goldstein, 1995). This view of entropy as disorder is a psychological interpretation: it does not necessarily follow from its mathematical definition as the measurement of the uniformity of the distribution of states in a histogram.

Undoubtedly friction reduces movement to heat, use produces wear and tear, and life leads to death, but just as evidently heat and action produce work, and life emerged from inorganic processes. According to the process perspective, physical processes spontaneously create life and consciousness. Energy, like time, always flows, and can be used profitably, or wasted. Open processes tend not only to static equilibrium points, but also to periodic and chaotic attractors; the equilibrium of opposite forces also creates structures. We thus enlarge the concept of entropic equilibrium to include all forms of symmetry of opposites, not only disorder and uniformity, but also organization. Evolution unfolds an infinite attractor of ever-increasing complexity, rather than decaying toward entropic equilibrium.

The creation of organization necessitates a greater flow of energy than simpler mechanical or disordering processes. Energy flow accelerates with evolution (Swenson, 1989). The free energy flow density in human brain ( $150,000 \text{ ergs sec}^{-1} \text{ g}^{-1}$ ) is much higher than that of any other system (e.g., it is  $2 \text{ ergs sec}^{-1} \text{ g}^{-1}$  for the sun) [Chaiisson, 1987]. Thus, we propose that biological and psychological processes markedly increase entropy (Sabelli, 1989), at variance with the proposed association of biological processes with a lowering of internal entropy.

Swenson (1989) proposed as a principle that entropy increases at the fastest possible rate. As organized flows are faster and hence produce more entropy, processes spontaneously self-organize. In our view, the maximization



of entropy is an enantiodromia that includes both progress and decay, ordering and disordering, creative individuation and pathological deviation. Creativity can be fostered by an increase in energy consumption rather than by a tendency to equilibrium. This idea fits the enhanced creativity of bipolar personalities (Andreasen, 1987), and suggests stimulation, encouragement and expectations as psychotherapeutic interventions.

### *Thermodynamic Method*

(1) Measure the entropy of psychobiological processes in multidimensional frameworks, by computing the entropy of time series and of recurrences of pattern. (2) Compare the results with those obtained for simpler patterns to evaluate empirically the meaning of entropy measures.

*Experimental.* Comparison of computer generated distributions (random, periodic, chaotic) indicates that entropy measures the symmetry of the distribution, and the diversity of the data; it does not measure disorder (Carlson-Sabelli et al., 1996; Sabelli, Patel, et al., 1995). The entropy of recurrences correlates with temporal order and it is increased in psychotic patients, indicating that illness, and hence decay, is associated with excessive order rather than with disorder.

### **Organization: Priority of the Simple and Supremacy of the Complex**

#### *Process Principles*

Evolution generates a hierarchy of complexity. Simple processes have greater extension and duration. Complex processes organize the simple processes that encode them.

*Embedding and isomorphism of simple and complex processes.* Information is coded in physical action or matter. Thus, complex biological processes are homologous to the simple physical processes that generate and surround them. Simple processes are isomorphic to the complex processes they embody. Psychological processes organize the simpler physical entities that embody them, such as sequences of action potentials, which in turn are embodied in the physical movement of ions. Within an organism, the lower and the higher levels (molecular, biological, psychological) must thus have each other's form. For instance, the timing of the heart portrays the behavior of the organism. Complexity is not reducible: human life is a psychological process, not merely a biological one.

*Levels.* Simpler processes contain (and are contained within) the more complex processes they generate. Evolution creates hierarchies in levels of organization (mathematical, physical, chemical, biological, social, psychological), in brain structures (spinal, bulbar, mesencephalic, diencephalic, corti-

cal), and in psychological functions (Maslow's [1970] hierarchy of needs and wants). Levels of complexity differ from hierarchies determined by the extension of systems (atom, molecule, cell, organism, planet, solar system); the systems perspective splits the physical level, cannot separate the biological and the psychological levels, and places the social above the personal. As a totality, society has greater energy and complexity than individuals (priority), but each individual mind has greater energetic and informational density (supremacy). Also, social processes have temporal priority over individual psychological processes in evolution, in individual life, and in personal interactions (we first see the social role, only later the individual person).

*Priority and supremacy.* Spinal cord and brain cortex, heart and brain, brain and psyche, personal survival and altruistic sacrifice, sexuality and meaning, illustrate the concept of priority of the simple and supremacy of the complex (Sabelli, 1989; Sabelli and Carlson-Sabelli, 1989). In all processes the simpler levels predominate globally because they have more energy, more extension, more duration, and temporal priority. The more complex processes predominate locally, because they have greater density of energy flow and of information. In contrast, materialism and idealism give absolute priority to either matter or ideas. Postulating that social roles and social systems precede individual differentiation contrasts with the systems' bio-psycho-social model, with significant consequences for the understanding of personality, life history, and pathology. Illustrating *biological priority*, many affective disorders require pharmacological treatment; demonstrating *psychological supremacy*, emotions modify metabolism and contribute significantly to medical illness. These concepts underlie the *bio-socio-psychological* approach to diagnosis and treatment described elsewhere (Sabelli and Carlson-Sabelli, 1989, 1991). Recognizing that emotions must be coded in synaptic transmitters and modulators, has led to the search for a neurohormonal deficit in depression. There is a reduction in the metabolism of phenylethylamine (PEA), a neurohormone that increases psychological energy and libido, in sixty percent of depressed patients (Sabelli and Javaid, 1995). PEA replacement controls depression in sixty percent of patients (Sabelli, Fink, Fawcett, and Tom, 1996), suggesting that a common form of depression results from a metabolic deficit just like diabetes. Depressing events such as divorce markedly modify PEA metabolism. The treatment of depression thus requires both correction of metabolic dysfunctions and psychotherapeutic intervention.

*Priority of the objective and the supremacy of the subjective.* Objective facts and brain physiology predetermine psychological processes, but cultural and psychological processes interpret perceptions. The therapist must seek the objective truth, rather than be content with the patient's "subjective truth," which may not be true at all. Yet subjective interpretation is unavoidable, and must be attended to constantly. This concept applies not only clinically

(Carlson-Sabelli and Sabelli, 1984) but also scientifically (Sabelli and Carlson-Sabelli, 1996b).

*Comprehensive Method: Mathematical Priority and Psychological Supremacy*

Science needs mathematics: nonlinear dynamics may provide it for psychodynamics. Yet the application of biocybernetics, systems, chaos and complexity to psychological processes is a field populated by models, with a paucity of data. This cannot be a healthy state of affairs. In our view, the lack of data reflects the limitations of static models. Techniques appropriate to demonstrate the presence of deterministic chaos in physical data fail to do so in the case of biological and psychological processes (Rapp, 1995), not because it is difficult to obtain reliable stationary data, but because processes, whether physical or biological, are neither stationary nor isolated. Adherence to static models may actually hinder the application of dynamics to psychodynamics. Stable, deterministic, low dimensional, and mutually exclusive attractors cannot model changing, creative, multidimensional, and interacting psychological processes. Unconscious cultural and psychological bias pervades scientific modeling: stress on stable attractors shows a conservative bias in dynamics; emphasis on *self*-organization and on interaction-free attractors evidences individualism; dialectic models show the paraconsciousness of conflict; reversible time reeks of wishfulness; equating entropy maximization with disordering discloses pessimism. Psychological analysis can help us to overcome such bias, and can also offer positive contributions. Following Pasteur's intellectual leap, we take human creations as a model for both physical and psychological processes. We thus propose that simple cosmic forms are the creators rather than the attractors of evolution.

*Process Theory of Psychology and Psychotherapy*

As a discipline and as a practice, psychology must deal with biological, social and personal processes. A comprehensive theory is required. Eclectic combination of disparate theories and methods is not adequate, or even possible, given fundamental contradictions between conceptual frameworks. Moreover, substantial modifications of current theories are required. Stress on harmony or on struggle neglects, and even impedes, creative evolution. The essential creative features of psychological processes are unaccounted for, when not excluded, by the determinism that dominates biological psychiatry, psychoanalysis, behaviorism, Marxism, and chaos theory; or they remain unexplained as accident or contingency in Darwinian evolutionary theory. Determinism and probability, harmony and struggle, biological analysis and individual subjectivity, each of these dichotomies must be included together with a third alternative, co-creation, which is the opposite of the

other two rather than their dialectic synthesis. The scientific formulation of the concept of co-creation provides a method for scientific research, social action, and clinical practice: attend to, and foster multiple mutual actions between opposites at each level of organization, and between simple and complex levels of organization in each process. In summary, process theory represents a new world view that focuses on creative processes, provides a mathematical formulation, and an empirical methodology, and integrates biological and psychological interventions in clinical practice.

### References

- Anderson, P.W., and Stein, D.L. (1987). Broken symmetry, emergent properties, dissipative structures, life: Are they related? In E.E. Yates (Ed.), *Self-organizing systems the emergence of order* (pp. 445-457). New York/London: Plenum.
- Andreasen, N.C. (1987). Creativity and mental illness: Prevalence rates in writers and their first degree relatives. *American Journal of Psychiatry*, 44, 1288-1292.
- Bateson, G. (1979). *Mind and nature. A necessary unity*. New York: Dutton.
- Bailey, K.D. (1994). *Sociology and the new systems theory*. Albany: State University of New York.
- Beck, A., Rush A., and Shaw B. (1979). *Cognitive therapy of depression*. New York: Guilford.
- Bem, S.L. (1974). The measurement of psychological androgyny. *Journal of Consulting and Clinical Psychology*, 42, 133-162.
- Bertalanffy, L.O. von. (1968). *General systems theory*. New York: George Braziller.
- Callahan, J., and Sashin, J.I. (1987). Models of affect-response and anorexia nervosa. *Annals New York Academy Sciences*, 504, 241-259.
- Carlson-Sabelli, L., and Sabelli, H.C. (1984). Reality, perception, and the role reversal. *Journal of Group Psychotherapy, Psychodrama and Sociometry*, 36, 162-174.
- Carlson-Sabelli, L., and Sabelli, H.C. (1992a). Interpersonal profiles: Analysis of interpersonal relations with the phase space of opposites. *Proceedings of the International Society for the Systems Sciences, USA*, 668-677.
- Carlson-Sabelli, L., and Sabelli, H.C. (1992b). Modular organization of human systems: A process theory perspective. *Proceedings of the International Society for the Systems Sciences, USA*, 678-688.
- Carlson-Sabelli, L., and Sabelli, H.C. (1992c). Phase plane of opposites: A method to study change in complex processes and its application to sociodynamics and psychotherapy. *The Social Dynamicist*, 3, 1-6.
- Carlson-Sabelli, L., Sabelli, H.C., and Hale, A. (1994). Sociometry and sociodynamics. In P. Holmes, M. Karp, and M. Watson (Eds.), *Psychodrama since Moreno: Innovations in theory and practice* (pp. 146-185). New York/London: Tavistock.
- Carlson-Sabelli, L., Sabelli, H.C., Hein, N., and Javaid, J. (1990). Psychogeometry: The dynamics of behavior. *Proceedings of the International Society for the Systems Sciences, USA*, 769-775.
- Carlson-Sabelli, L., Sabelli, H.C., Messer, J., Patel, M., Sugerman, A., Luecht, R., and Walthall, K. (1996). Cardiac entropy is decreased in coronary artery disease: Clinical and physical significance. *Proceedings of the International Society for the Systems Sciences, USA*, 165-176.
- Carlson-Sabelli, L., Sabelli, H.C., Patel, M., and Holm, K. (1992). The union of opposites in sociometry: An empirical application of process theory. *The Journal of Group Psychotherapy, Psychodrama and Sociometry*, 44, 147-171.
- Carlson-Sabelli, L., Sabelli, H.C., Patel, M., Messer, J., Zbilut, J., Sugerman, A., Walthall K., Tom, C., and Zdanovics, O. (1995). Electropsychoecardiography: Illustrating the application of process methods to comprehensive patient evaluation. *Complexity and Chaos in Nursing*, 2, 16-24.
- Carlson-Sabelli, L., Sabelli, H.C., Zbilut, J., Patel, M., Messer, J., Walthall, K., Tom, C., Fink, P., Sugerman, A., and Zdanovics, O. (1994). How the heart informs about the brain. A pro-

- cess analysis of the electrocardiogram. In R. Trappl (Ed.), *Cybernetics and Systems '94* (pp. 1031–1038). Singapore: World Scientific.
- Chaisson, E. (1987). *The life era*. New York: Atlantic Monthly Press.
- Cloninger, R.D. (1987). A systematic method for clinical description and classification of personality variants. *Archives of General Psychiatry*, 44, 573–588.
- Clynes, M. (1969). Cybernetic implications of rein control in perceptual and conceptual organization. *Annals New York Academy of Sciences*, 156, 629–670.
- Cohen, J., and Steward, I. (1994). *The collapse of chaos*. New York: Penguin.
- Cook, T.A. (1979). *The curves of life*. New York: Dover. (originally published 1914)
- Costa, P.T. (1996). Personality theories in the wake of the Five-Factor Model. *International Journal of Psychology*, 32, 432
- Corballis, M.C., and Beale, I.L. (1976). *The psychology of left and right*. Mahwah, New Jersey: Erlbaum.
- Csikszentmihalyi, M. (1990). *Flow. The psychology of optimal experience*. New York: Harper and Row.
- Devaney, R.L. (1989). *An introduction to chaotic dynamical system* (second edition). Redwood City: Addison Wesley.
- Engels, F. (1940). *Dialectics of nature*. New York: International Publishers.
- Goldstein, J. (1995). Unbalancing psychoanalytic theory: Moving beyond the equilibrium model of Freud's thought. In R. Robertson and A. Combs (Eds.), *Chaos theory in psychology and the life sciences* (pp. 239–251). Mahwah, New Jersey: Erlbaum.
- Guastello, S.J. (1987). A butterfly catastrophe model of motivation in organizations: Academic performance. *Journal of Applied Psychology*, 72, 165–182.
- Haldane, J.B.S. (1960). Pasteur and cosmic asymmetry. *Nature*, 185, 87.
- Hall, D.P., Sing, H.C., and Romanoski, A.J. (1991). Identification and characterization of greater mood variance in depression. *American Journal of Psychiatry*, 148, 1341–1344.
- Hartmann, H. (1958). *Essays on ego psychology: Selected papers on psychoanalytic theory*. New York: International University Press.
- Kauffman, L., and Sabelli, H.C. (1997). The process equation: A mathematical model of primary processes and psychophysiological organization. *Proceedings of the International Society for the Systems Sciences, Korea*, 881–897.
- Killeen, P.R. (1992). Mechanics of the animate. *Journal of Experimental Analysis of Behavior*, 57, 429–463.
- Kohut, H. (1971). *The analysis of the self*. New York: International Universities Press.
- Levine, D.S., and Leven. (1995). Of mice and networks. In F.D. Abraham and A.R. Gligen (Eds.), *Chaos theory in psychology* (pp. 205–219). Westport, Connecticut: Praeger.
- May, R.M. (1976). Simple mathematical models with very complicated dynamics. *Nature*, 261, 459–467.
- Maslow, A.H. (1970). *Motivation and personality*. New York: Harper and Row.
- Parsons, T. (1951). *The social system*. New York: The Free Press.
- Pattee, H.H. (1973). Unsolved problems and potential applications of hierarchy theory. In H.H. Pattee (Ed.), *Hierarchy theory* (pp. 71–108). New York: George Braziller.
- Prigogine, I., and Stengers I. (1984). *Order out of chaos, man's new dialogue with nature*. New York: Bantam.
- Raaz, N., Carlson-Sabelli, L., and Sabelli, H.C. (1992). Psychodrama in the treatment of multiple personality disorder: A process theory perspective. In E. Klufft (Ed.), *Expressive and functional therapies in the treatment of multiple personality* (pp. 169–188). Springfield, Illinois: Charles Thomas.
- Rapp, P.E. (1995). Is there evidence for chaos in the human central nervous system? In R. Robertson and A. Combs (Eds.), *Chaos theory in psychology and the life sciences* (pp. 89–100). Mahwah, New Jersey: Erlbaum.
- Redington, D.J., and Reidbord, S.P. (1992). Chaotic dynamics in autonomic nervous system activity of a patient during a psychotherapy session. *Biological Psychiatry*, 31, 993–1007.
- Robertson, R. (1989). The evolution of number. *Psychological Perspectives*, 20, 128–141.
- Sabelli, H.C. (1989). *Union of opposites: A comprehensive theory of natural and human processes*. Lawrenceville, Virginia: Brunswick.

- Sabelli, H.C., and Carlson-Sabelli, L. (1989). Biological priority and psychological supremacy, a new integrative paradigm derived from process theory. *American Journal of Psychiatry*, 146, 1541-1551.
- Sabelli, H.C., and Carlson-Sabelli, L. (1991). Process theory as a framework for comprehensive psychodynamic formulations. *Genetic, Social, and General Psychology Monographs*, 117, 5-27.
- Sabelli, H.C., and Carlson-Sabelli, L. (1992). Process theory: Energy, information and structure in the phase space of opposites. *Proceedings of the International Society for the Systems Sciences, USA*, 658-667.
- Sabelli, H.C., and Carlson-Sabelli, L. (1995). Sociodynamics: The application of process methods to the social sciences. In A. Albert (Ed.), *Chaos in society* (pp. 117-140). Amsterdam: IOS.
- Sabelli, H.C., and Carlson-Sabelli, L. (1996a). A cosmic gene? A biological model of complex systems. *Proceedings of the International Society for the Systems Sciences, USA*, 531-542.
- Sabelli, H.C., and Carlson-Sabelli, L. (1996b). As simple as one, two, three. Arithmetic: A simple, powerful, natural and dynamic logic. *Proceedings of the International Society for the Systems Sciences, USA*, 543-554.
- Sabelli, H.C., Carlson-Sabelli, L., and Javaid, J.I. (1990). The thermodynamics of bipolarity: A bifurcation model of bipolar illness and bipolar character and its psychotherapeutic applications. *Psychiatry: Interpersonal and Biological Processes*, 53, 346-367.
- Sabelli, H.C., Carlson-Sabelli, L., and Messer, J. (1994). The process method of comprehensive patient evaluation based on the emerging science of complex dynamic systems. *Theoretic and Applied Chaos Theory in Nursing*, 1, 33-41.
- Sabelli, H.C., Carlson-Sabelli, L., Patel M., Levy, A., and Diez-Martin, J. (1995). Anger, fear, depression and crime. Physiological and psychological studies using the process method. In R. Robertson and A. Combs (Eds.), *Chaos theory in psychology and the life sciences* (pp. 65-88). Mahwah, New Jersey: Erlbaum.
- Sabelli, H.C., Carlson-Sabelli, L., Patel, M., Zbilut, J., Messer, J., and Walthall, K. (1995). Psychological portraits and psychocardiological patterns in phase space. In F.D. Abraham and A.R. Gilgen (Eds.), *Chaos theory in psychology* (pp. 107-125). Westport, Connecticut: Praeger.
- Sabelli, H.C., Fink, P., Fawcett, J., and Tom, C. (1996). Sustained antidepressant effect of PEA replacement. *Journal of Neuropsychiatry*, 8(2), 168-171.
- Sabelli, H.C., and Javaid, J. (1995). Phenylethylamine modulation of affect: Therapeutic and diagnostic implications. *Journal of Neuropsychiatry*, 7(1), 6-14.
- Sabelli, H.C., Patel, M., Carlson-Sabelli, L., Sugerman, A., and Messer, J. (1995). Entropy as diversity and organization in living systems. *Proceedings of the International Society for the Systems Sciences, Amsterdam*, 13-124.
- Sennett, R., and Cobb, J. (1973). *The hidden injuries of class*. New York: Vintage.
- Shannon, C.E., and Weaver, W. (1949). *The mathematical theory of communication*. Urbana, Illinois: University of Illinois.
- Steward, I.N., and Peregoy, P.L. (1983). Catastrophe theory modeling in psychology. *Psychological Bulletin*, 94, 336-362.
- Swenson, R. (1989). Emergent attractors and the law of maximum entropy production: Foundations to a theory of general evolution. *Systems Research*, 6, 187-197.
- Thom, R. (1975). *Structural stability and morphogenesis*. Reading, Massachusetts: Benjamin/Cummings.
- Thom, R. (1983). *Mathematical models of morphogenesis*. Chichester, West Sussex: Ellis Horwood.
- Torre, C. (1995). Chaos in the triadic theory of psychological competence in the academic setting. In F.D. Abraham and A.R. Gilgen (Eds.), *Chaos theory in psychology* (pp. 279-294). Westport, Connecticut: Praeger.
- Vandervert, L.R. (1988). Systems thinking and a proposal for a neurological positivism. *Systems Research*, 5, 313-321.
- Wallston, K.A., Wallston, B.S., Smith, S., and Dobbins, C.G. (1987). Perceived control and health. *Current Psychological Research and Reviews*, 6, 5-25.
- Webber, Jr., C.L., and Zbilut, J.P. (1994). Dynamical assessment of physiological systems and states using recurrence plot strategies. *Journal of Applied Physiology*, 76, 965-973.
- Yorke, J.A., and Li, T.-Y. (1975). Period three implies chaos. *American Mathematical Monthly*, 18, 985-992.