BIPOLAR FEEDBACK

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Keywords: Bios, chaos, cosmology, economics, heart, feedback, psychotherapy, quantum physics.

Contents

Summary

Bipolar feedback is a creative process present in many natural and human systems. Feedback is usually bipolar—that is, positive and negative—in natural environments, which, in their diversity, furnish synergic and antagonistic responses to the output of any system. Trigonometric models of bipolar feedback generate convergence to a steady state, periodicity, chaos, bios, and leaps. (In contrast, models of unipolar feedback such as the logistic equation generates only steady states, periodicity, and chaos.) Bios is a sequence of episodic patterns (complexes) that expands in amplitude and morphological diversity with time, in contrast to mechanical, periodic, and chaotic patterns that remain uniform in time. Biotic series are more variable than their randomized copies, demonstrating novelty. Diversity, novelty, complexity, and episodic patterning are hallmarks of creativity. Biotic patterns are observed in physical, biological, and economic processes, including quantum physics (Schrödinger's wave function), the temporal distribution of galaxies, air and ocean temperature, geographical structures, sequences of bases in DNA, biological: population size, physiological processes (heartbeat intervals, respiration), economic series (prices, stocks, currencies), and some literary texts and musical compositions. This widespread occurrence of bios suggests that bipolar feedback may generate many aperiodic processes currently attributed to random change or to chaos. Bipolar feedback may be one of the processes through which interactions create novelty, complexity, and diversity in cosmological, biological, and socioeconomic evolution. In mathematical models, the complexity of patterns generated by bipolar feedback increases with the intensity, diversity, and symmetry of the bipolar feedback, suggesting guidelines for promoting creativity in social and personal development.

1. Introduction

This article describes a new cybernetic concept: bipolar feedback, a creative process present in many natural and human systems. The concept of feedback opened new vistas in both biology and engineering. In biology, negative feedback contributes to the regulation of movement, and the maintenance of homeostasis. In engineering, negative feedback is accomplished by returning part of the output of a system as part of its input, and thereby information about results of a process is used to change the process itself. Self-reinforcing feedback has been regarded as producing runaway effects or vicious cycles. Actually, self-reinforcing positive feedback can also contribute to creation as illustrated by Prigogine's notion that self-amplifying fluctuations are a source of organization.

Whereas positive and negative feedback mechanisms have found a wide range of applications in engineering, natural and human processes invariably include both. Current studies with mathematical models indicate that bipolar feedback creates complex patterns (bios) that uniquely resemble those found in physical, physiological, socioeconomic, and other empirical data. It seems likely that bipolar feedback contributes substantially to the generation of creative phenomena in natural and human processes. If positive feedback processes predominated, there would be no check to exponential growth, in which plants become invading weeds, animals become pests, beliefs become self-fulfilling prophecies, and ideas are enthroned by bandwagon effects. Conversely, if negative feedback predominated absolutely, there would be little change, and no evolution. The creation of organization requires a combination of positive and negative feedback (see *Cybernetics and the Integration of Knowledge*).

2. Bipolar Feedback in Natural Processes

Feedback is a universal and fundamental process in nature. Organisms, biological communities, and ecological systems continually interact with their environment, and thereby receive ceaseless feedback. The inputs received by a system are at least in part reactions to its previous action; in turn, each input contributes to determination of the following action. Through its repetitive interactions with others, each system becomes both self-referential and co-creative. A biological organism, with its receptors and effectors, forms, with the environment, a system with feedback, in which the organism chooses its goals and the environment provides necessary information. The same feedback process obtains between persons and their interpersonal world, institutions and society, a country and the world. Feedback is not a special process that obtains only in particular systems or organisms.

Regarding feedback as a universal and fundamental process in nature, it behooves us to define it in terms of fundamental physical entities and mathematical structures. Feedback is a relation in which repetitive interaction between component processes provides information, and thereby creates and transforms patterns of organization. Action, information, and organization are the three central concepts.

Action is a temporal transformation of energy. Everything is energy, because all forms

of energy convert into each other (the first law of thermodynamics), and matter also converts to energy (Einstein's law). Energy is conserved as a quantity, but it exists only as it changes in time. Not only energy is universal, but also time. The Planck quantum has the dimensions of action, that is to say, energy and time; as nothing can be smaller or simpler than the quantum, everything has the dimensions of action. This physical concept of action can be readily generalized to apply to biological, economic, and psychological processes. Thinking in terms of action, rather than energy, stresses both the conservation of energy and the unidirectional change of time. It also points to the discrete nature of action units (e.g., Planck's quanta, cardiac contractions, the life of an individual). In the models, A_t, $A_{t+1}...A_{t+i}$ indicate the temporal sequence of action *A* at each successive moment of time *t*. Energy being conserved, each action A_{t+1} continues the previous action A_t. Unidirectional order and transitivity characterize the order of lattices, one of the three fundamental structures of mathematics.

Information. Opposition is in nature what information is in computation and negation is in logic. Information is encoded in the sequence of two or more actions. In a relatively stable system, a change $\Delta A_t = A_t - A_{t+1}$ from one value to another carries information. In rapidly changing processes, repetition ($\Delta A_t = 0$) carries information. Fundamental information is carried by bipolar oppositions (such as up and down spin, positive and negative electrical charge, male and female) as contrasted to unipolar statements of existence (what is and what is not). Context is essential: the opposite of an electron is a proton in the hydrogen atom and a positron in a bubble chamber. Within each context, for each action, property or entity, there is an opposite action, so the set of choices forms a group, the second fundamental mathematical structure. (In contrast, standard logic models negation by set theory complementation, the unipolar difference between what is and what is not. From the perspective of group theory, an opposition is a rotation, as exemplified by quantum spin or the spinning of the planet that brings about the opposition of day and night. In natural systems as well as in mathematical recursions, there are multiple bifurcations that multiply the number of oppositions thereby creating information and complexity.

Creation of organization. A third feature of all processes is the creation of organization. Substance is conserved. Forms are created and recreated by the making and breaking of connections. Elementary particles, structures, organisms, and ideas are not different substances; they are patterns of organization. Life is pattern rather than substance. "We are but whirlpools in a river of ever flowing water;"", said Wiener paraphrasing Heraclitus, "We are not the stuff that abides, but patterns that perpetuate themselves." They do not perpetuate themselves for long. Patterns are continually created, transformed, and replaced. Form and transformation are the subject matter of topology, the third mother structure of mathematics. Using its methods, patterns can be mapped and measured. Patterns can be transient or stable (equilibrium, structure), transformation can be continuous (rubber geometry) or discontinuous (bifurcation). In either case, there is both conservation and change: $A_{t+1} = A_t + \Delta A_t$. Each action A_{t+1} continues the previous action A_t, and incorporates the change ΔA_t, resulting from its interactions with other systems. Change is a function of A_t, so ΔA_t is feedback. In natural environments, some responses to a given action are synergistic and others are

antagonistic, one or the other sign predominating at different times, as contrasted to purely positive and purely negative feedback mechanisms that can be constructed in artificial systems.

Natural feedback is both bipolar and diverse. Random environments will generate diverse actions that appear to the system as synergic and antagonistic responses to its output. Nonrandom natural processes contain opposites that imply each other (e.g., action and reaction, positive and negative electrical charges, two sexes) and will generate positive and negative reactions to the output of any system. Thus natural systems continually receive synergic and antagonistic inputs, and continually generate outputs that are synergic to some systems in their environment and opposed to others.

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Biographical Sketch

Hector Sabelli is an Argentine-American scientist and psychiatrist, and current director of the Chicago Center for Creative Development. His major contribution—co-creation theory and method—integrates empirical research, clinical studies, and mathematics within the context of a process philosophy. It has generated statistical and dynamic methods to analyze empirical data, a mathematical model for heart rate variation, and a comprehensive approach to patient care that gives priority to biology and supremacy to psychology. His best-known work is the discovery of phenylethylamine, a stimulant neurohormone reduced in depression that can be used for its treatment. He has written numerous scientific articles published in leading journals *(Nature, Science, American Journal of Psychiatry, Archives of Internal Medicine, International Journal of General Systems, Journal of Neuropsychiatry)*, and five books, including *Union of Opposites: A Comprehensive Theory of Natural and Human Processes* (1989). He received his M.D. degree from the University of Buenos Aires, Argentina, and did his Ph.D. thesis research in pharmacology at the Chicago Medical School. He has been Professor and Director of the Institute of Pharmacology, University of Litoral, Argentina; Professor and Chairman, Dept. Pharmacology, University of Health Sciences, Chicago, Illinois, US; and Professor of Pharmacology and Associate Professor of Psychiatry, Rush University, Chicago, US. He has received numerous awards in pharmacology and psychiatry, including a Doctorate Honoris Causa from the University of Rosario, Argentina.