Organizational Leader Development

A Dynamic Systems Perspective of Workplace Cognition

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Pepper and his metaphors

Much of the foundational understanding contained in this essay is built upon the work of Stephen Pepper's (1942) discourse on the theories of human development and, especially, the reflections thereof contained in Dale Goldhaber's (2000) *Theories of Human Development: Integrative Perspectives.* Goldhaber attests that Pepper's work provides a means to examine and understand the "common thread that run between theories" (2000, p. xiii). Others recognize Pepper's "root metaphor" notion as a rich and useful scheme for organizing theories (see, e.g., Super & Harkness, 2003). Such use is reflected in common, practical application as when applied in cognitive systems used to interpret child behavior (Super & Harkness, 2003). This is understandable. While theories are constructed from the reasoning of scientists as they "sift through empirical facts" (Thomas, 1996), they are "living things" and, therefore, subject to change and evolution (Goldhaber, 2000, p. xiv). The progressive growth of theories has lead experts in human development to vary among themselves in how they think about their field of expertise (Super & Harkness, 2003). Organizing them, as Pepper has done, provides a useful tool for conceptualizing, categorizing, and taking theories to practice.

There is a recognized and accepted risk in using Pepper's notion of theory organization, however. His work is not without its critics. Pepper's work is a source of debate (Morris, 1997). Relative to the mechanism-contextualism debate, Morris, reflective of the critical stance toward Pepper's work, lists two fundamental reasons for their criticism: 1) his work as a an "impossible exercise in German idealism" and, 2) as "nonsensical because it cannot be verified in the logical positivists tradition" (1997, p. 530). Secondary sources to Pepper's original work "compound the problem" (Morris, 1997). Goldhaber's (2000) work, as an example, omits Pepper's metaphor of "formalism", one of Pepper's theory of four "root metaphors" (see, e.g., Super & Harkness, 2003). Even with its criticism, Pepper's metaphors for human development theories continues, as suggested by Super and Harkness (2003), to be widely used by parents and mental health professionals in interpreting child behavior. "Truth is always relative to a conceptual system that is defined in large part by metaphor" (Super & Harkness, 2003, p. 7).

Human development: A definition

Human development, variously referred to as child development (e.g., Super & Harkness, 2003), child psychology (e.g., White & Cahan, 1997), developmental psychology (e.g., Callaghan, 1993; Mueller, 2004; Schwarzer, 1999), and cognitive development (e.g., Yan & Fischer, 2002), generally incorporates into its definition an aspect of psychological change that occurs across the lifespan (Dictionary, 2003). Others, sensitive to the culture in which human development occurs, include in their definition a distinct reference to the life span acquisition of "cultural knowledge and performance capabilities" (Erickson, 2002). Beyond definition, describing human development involves addressing fundamental questions, such as who changes? What changes? When and why does it change? (Mueller, 2004) or How do we change? Why do we change over time? What determines the particular content of our individual lives? (Goldhaber, 2000). How human development theorists answer these questions will lead to differences in how they define the subject (Super & Harkness, 2003). However defined, the field is considered "one of the most dynamic and interesting areas of psychology" (Hothersall, 1990, p. 447).

Chronicle of a discipline: A brief history of human development

When reviewing the history of human development one will invariably find reference to Jean Piaget (Piaget, 1950). He is considered to have had the greatest impact on developmental psychology (Lourenco, 1996). However, the historical roots of human development studies go much deeper. Some believe that there has always been an integral element of psychological development included in any study of psychology (Callaghan, 1993). When researching the intellectual lineage of this field it is advisable to remain cognizant that “the development of developmental psychology is not so neatly localized” (White & Cahan, 1997). There are various accounts of and interpretations of the foundation of the human development field.

Darwin may have been the first contributor to the field, the “point of departure” (Charlesworth, 1992) for distinct developmental lines for various families of theories. Many of the early researchers held an evolutionary point of view (see, e.g., Hothersall, 1990, James Baldwin, pp. 122-123, G.S. Hall, pp. 289-299), assimilating Darwin’s ideas into their own (Charlesworth, 1992). Darwin had “inspired” psychologists of the period to study learning and intelligence (Kalat, 1993, pp. 277-278). Some contend that the “formal beginning” of the field is marked by G.S. Hall’s 1904 publication *Adolescence* (Hothersall, 1990, p. 447). However, James Baldwin, conducting much of his work in the late 1800s (Hothersall, 1990), held the conviction that that any study in psychology must be grounded in the study of human development (Callaghan, 1993). These early human development researchers, forming the anchor points of distinct lines of thought which shaped the field (Charlesworth, 1992), may have followed independent lines of reasoning not based solely on intellectual differences, but also political and personal (see, e.g., Hothersall, 1990, Baldwin's colleague, James Cattell, assertion that G.S. Hall's editorial work on the American Journal of Psychology was "a disgrace", p. 292).

Their differences established not only different schools of thought but also records of work in the field. James Cattell and James Baldwin went on to found the journal *Psychological Review* while G. Stanley Hall edited the rival *America Journal of Psychology* (Hothersall, 1990).

As noted, some historians contend that there are “major lines of thought” that shaped the field (see, e.g., Charlesworth, 1992), others describe as “waves” the periods of significant development in the field (White & Cahan, 1997). They recount how the 1890s and early 1900s, with university-based research, marks the first wave of development in the field of developmental psychology. The second and third waves of development followed, respectively, were in the 1930s (see, e.g., Hothersall, 1990, Carl Murchinson's Handbook of Child Psychology, p. 202) and 1960s (see, e.g., Hothersall, 1990, Chomsky: 1965 innate language, Paivio: 1969 mental imagery, Sternberg: 1966 short-term memory p. 1447). These two concepts of developmental work, coupled one with the other, are depicted in Table 1.

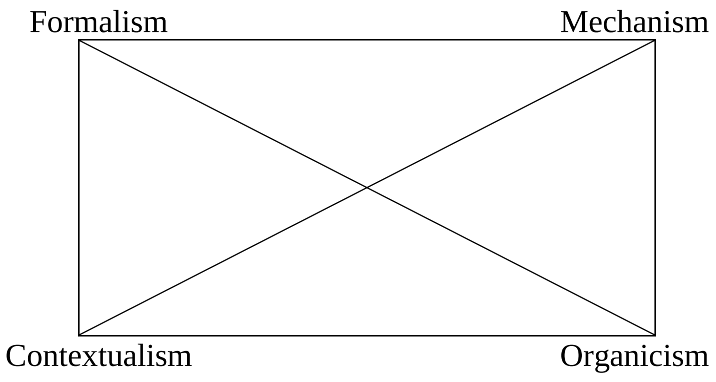
Table 1. Topology of Developmental History

	Wave 1: 1890-1920	Wave 2: 1930s	Wave 3: 1960s
Line 1	Baldwin, Cattell, Watson		Skinner, Piaget
Line 2	Preyer, Hall	Gesell	
Line 3	Freud, Eriksen		

While early developmental research followed distinct lines of thought, much of this work has similar characteristics. These “grand theories” exhibit “convergence”, where each set of theories are applicable across individuals and context, and “connection”, in that there is a line between theory, method, and application (see Schwarzer, 1999, for expanded discussion). They provide, then, general models of human development.

It is, however, generally accepted that these sets of theories are incompatible (Super & Harkness, 2003), irreconcilable (Mueller, 2004), and that dialogue among them is impossible (Goldhaber, 2000). Experts grounded in each theoretical concept varies with others similarly grounded in a different school of thought on what development is (Super & Harkness, 2003). However, Pepper found, “to his own surprise” (Super & Harkness, 2003, for expanded discussion), that these theories can be grouped into two groups of two. This is depicted in Figure 3. Some combinations hold more similarities than others. As an example, contextualism and organicism are both holistic, interactive views of development where individuals construct meaning of their experiences (Goldhaber, 2000, p. 298). Mechanicism and organicism share a belief in knowable, universal patters of behavior (Goldhaber, 2000, p. 295). Formalism and mechanicism are analytic, organicism and contextualism are synthetic (Super & Harkness, 2003, p. 6). Super and Harkness suggest that adjacent pairs in the table should have “minimal conflict” while the ones diagonally separated should be “strongly oppositional” (2003, p. 7). This concept, however, is strongly questioned by those holding the view that “contextualism may be little more than a complex version of mechanism” (Morris, 1997, p. 3).

Figure 3. Metaphor Relationship



Further debate has emerged as contemporary researchers question the validity of foundational notions underlying much of the “great theories”. Contemporary researchers adopt a “divergence” perspective, accepting that “specialization has emerged” (Schwarzer, 1999). Others contend that the traditional static concepts employed in the “great theories” are inadequate (Yan & Fischer, 2002) in that they are not fundamental to knowledge building in developmental psychology (White & Cahan, 1997). Much of contemporary work in human development has taken on a distinct *avant-garde* nature as they embrace the “new sciences” (see, e.g., Abraham & Gilgen, 1995; Kelso, 1995; Thelen & Smith, 1994). Modern human development theorists no longer look for rigid and inflexible schemes to explain the development phenomenon (Schwarzer, 1999), and many practitioners are adopting their new concepts (see, e.g., Miller, 1998).

Perspective on the mechanistic worldview

Pepper chose the machine as metaphor for this family of human development theories. It is quite appropriate. This selection of symbol is reflective of two interrelated phenomenon: The fundamental distillate of assumptions held in this set of theories and the foundational intellectual heritage and bias of the scientists working toward their development. Human development theories within this category, as Goldhaber expresses, are “reductionist perspectives” (2000, p. 21). They are, then, mechanical in their treatment of the subject (see, e.g., Chalmers, 1996, pp. 46-47, "Reductive explanations in cognitive science" section). They provide explanation of a phenomenon in terms of events or processes occurring at a lower or more basic level (Dictionary, 2003) or combinations of simpler components (Kalat, 1993). As depicted in Figure 1, much of the mechanistic view suggests a simple stimulus-response action. I recently explored (McElroy, 2004a, pp. 8-9) this phenomenon in science. These “mechanistic” human development theorists generally accepted strict “cause and effect” linkage of the traditional chain metaphor (Chiesa, 1992). Within such a concept, as expressed by B.F. Skinner, “feelings or states of mind… may be interpreted as collateral products” (1974, p. 68). The mind, then, seems almost a byproduct of the brain; behavior is a manifestation of the brains mechanical action. Behaviorists explain behavior by studying only observable behavior, not referencing unobservable mental processes (Kalat, 1993). The view is generally accepted within the field of behaviorism[1] (see, McElroy, 2003, pp. 35-44, Historical Concepts of Personality). Discovering the “laws” of behavior, is a “mechanical” matter of observation and interpretation (Combs & Snygg, 1959).

But one should question how these scientists came to accept such a mechanic view of development. I recently explored this issue relative to neuroscience (McElroy, 2004b see also Appendix I). Classic or Newtonian physics[2] holds a revered place in scientific belief. This includes neuroscience and, as suggested by the mechanical view espoused by this family of theorist, in the wide realm of general psychology, as well. Many contemporary works in neuroscience and related fields ascribe to this traditional system, citing “ordinary laws of physics”. The intellectual heritage concepts employed by these theorists that may have their roots in fundamental means of and core beliefs held by scientific exploration[3]. From the earliest days of scientific inquiry, men and women have assumed a “mechanical view” of reality. It played a major role in earlier work in the development of these theories. Theorists working in this realm believe that it is possible to “tease apart” (Goldhaber, 2000, p. 15) the various factors influencing behavior in that such stimulus is “fractionated into a multitude of elements” (Fanselow, 1999, p. 276). However, as contemporary research suggests, to do so would be to disregard the known neurological mechanisms at play (see, e.g., Cozolino, 2002; Fanselow, 1999; Schwartz & Begley, 2002).

Goldhaber (2000) lists the “primary quantities” of this family of theories, or those elements that define how it operates, as: Independent components in elemental and quantitative relationship. But what are the underlying assumptions made by these theorists? Goldhaber (2000, p. 151) lists them as:

1. It is possible to discover a set of universal laws;
2. These laws exist independent of our efforts to know them;
3. They are building blocks used to create behavior;
4. Behavioral change is quantitative.

Perspective on organismic worldview

Unlike the elemental view of the mechanistic worldview, the organismic view is one of integrated, synergistic whole (Goldhaber, 2000). Goldhaber points out that it is, then, more complicated (2000, p. 35). While the mechanistic view allows for a single, isolated stimulus-reaction perspective, that of organismic provides that something is always happening. It is, then, dynamic. This worldview is reflective of three “holistic” views: Systems theory[4], phenomenology, and humanistic psychology[5].

The fundamental beliefs held in the organismic worldview are that the whole is more than the sum of the parts[6], the whole creates force, and the elements acquire meaning through their interaction. This view is similar to that of systems theory. As depicted in Figure 1, organismic view holds that that there are naturally occurring patterns of psychological constructs that are not a direct function of the environment. They are a construct of the “meaning” ones ascribes to the environmental experience. As I explored (2004a) in my essay, *Circuitous Path to Organizational Systems*, the emergence of complex systems brought about the realization of the need for new scientific thinking (Banathy, 2004), constituting, in General Systems Theory, as suggested by Bertalanffy, a "second industrial revolution" (1969, p. 4). It is a "reorientation of scientific thinking" (1969, p. 5), and a "broad shift in scientific perspective" (1969, p. 17). While Newtonian physics searched deeper into the elemental constituent parts (Feynman, 2001; McElroy, 2004b; McEvoy & Zarate, 1996; Polkinghorne, 2002; Stapp, 1993), the emerging world-view from modern physics can be characterized as organic, holistic, and ecological (Mandel, 2004). It embraces, then, the whole.

Phenomenology, a "philosophy of consciousness" (Collins & Selina, 1998), and humanistic psychology[5], similarly, embrace the concept that it is only through a holistic perspective that one can understand. As Heidegger explained, what is central is "the being of Being" (see., e.g., Steiner, 1989). Heideggar emphasized that "*Dasein* is 'to be there, and 'there' is the world: the concrete, literal, actual, daily world. To be human is to be immersed, implanted, rooted in the earth, in the quotidian matter-of-factness of the world. A philosophy that abstracts, that seeks to elevate itself above the everydayness of the everyday, is empty" (Allen, 1985, p. 83). While "almost impossible to summarize, and wildly speculative" (Osborne, 1992), Heideggar reinforced the concept of going back to the phenomena, those things which appear to the consciousness. The mechanistic worldview "offered an approach to psychology that chooses to study the body, behavior, and what is objective and observable to the senses… it chose to exclude from study the mind, experience" (Valle & Halling, 1989, p. 63). As Valle and Halling contrast, phenomenological psychology, and those theories within the organismic worldview, provide a "holistic viewpoint, looking at the human being as a unity of body and mind, behavior and situation" (1989, p. 63). Behavioral change, then, is "inherent in the living organism itself rather than externally driven" (Goldhaber, 2000, p. 33). Valle and Halling (1989) found a "facilitative role" toward meaning in the experience of interaction, much as Goldhaber explains that "elements acquire their meaning only when they interact with other elements in the system" (2000, p. 33).

This family of theories is not without controversy. Organicism and, specifically, the age-stage theories are not as respected as they once were (Thomas, 1996). Primary issues involved in this controversy are its claim to a developmental endpoint, path or direction leaving unexplained the different life paths (Goldhaber, 2000, pp. 34-35) and "interdomain continuity" (see, e.g., Goldhaber, 2000, p. 43, expanded discussion of Damon's investigation relative to children's understanding of relationships in social domains). Thomas (1996, p. 1) reports that "substantial attention has been given to moving beyond" these organicism theories, incorporating a more socially-cognizant structure (*i.e.,* contextualism) to research.

Perspective on contextualist worldview

Pepper's root metaphor for this family of theories, the historical event (Goldhaber, 2000), is "opaque" (Morris, 1997) in that these theories are more reflective of America's contribution to philosophy (Osborne, 1992): Pragmatism. Pepper clearly made such an association by identifying the work of Charles S. Peirce, William James and John Dewey as reflective of contextualism (Morris, 1997). Peirce's philosophy was that there is a "relationship between thought and action" (Osborne, 1992, p. 138). James, expanding Pierce's foundational wisdom, outlining his philosophical tenets in his 1907 *Pragmatism* and 1909 *The Meaning of Truth* (see, e.g., Hothersall, 1990, pp. 283-284, "James as a Philosopher" section), espoused that "pragmatic criteria may be applied in establishing truth”. He believed that “ideas become true just so far as they help us to get into satisfactory relations with other parts of our experience” (Osborne, 1992, p. 139). Applauding Pierce, William James believed that pragmatism had disentangling the application of thought from its guiding principles (James, 1997, pp. 466-467). The only reason for thought in motion or action was the attainment of belief, or “thought at rest”. People, then, “self-construct” (Thomas, 1996) as the context in which action is taken is mentally transformed from near-inert setting to that of instrumental in establishing meaning (Figure 1). The environment and the resultant mental process ascribing meaning are entangled. As Goldhaber explains, “meaning of any behavioral event is dependent on the context in which it occurs” (2000, p. 47). Dewey was especially critical of the mechanistic precepts of simple stimulus-response (Hothersall, 1990, pp. 303-304) where mental activity is seen as collateral and not essential to operation (see., e.g., Goldhaber, 2000, p. 17; Skinner, 1974, p. 68). He contended that behavior and consciousness cannot be arbitrarily broken apart, but rather play a role in allowing ones adjustment to the environment. Stimuli, then, is seen as “psychological events, not simply as physical energies from the environment” (Hothersall, 1990, p. 304).

Goldhaber (2000, p. 51) lists the fundamental principles for the contextualist family of theories as:

1. Emphasis on the practical and the immediate (see, e.g., Erickson, 2002, p. 4, "individual's daily rounds", social situations and "real-time, continuous social action");
2. Individuals as active meaning makers (see. e.g., Thomas, 1996, p. 3"individuals are sole creators of their worlds and their development");
3. Open-ended nature of human development;

4. Scientific inquiry as fallible, human endeavor.

The basic aspects of these theories, include (Thomas, 1996):

1. An emphasis on second-order structural change (i.e., progressive, hierarchic construction of models of reality, experience is shaped into cognitive schemas) over firsts-order belief changes;
2. An emphasis on individual as *autopoiesis* (Greek, self-production) self-organizing system;
3. An emphasis on the necessity of crisis for constructive change.

While contextualists question mechanism's objectivity and organicist's directional development (Goldhaber, 2000), some believe that they embrace all the worldviews as "theories of truth" (Morris, 1997, p. 533).

In-Depth

A Perspective in Focus: Dynamic systems and cognitive development

Hypothesis: Dynamic Systems in Cognitive Developmental Psychology

Computational Hypothesis. Computational hypothesis (CH), the claim that cognitive agents are digital computers, has been a dominate view of cognitive science since the late 1950s (van Gelder, 1998). It continues to be considered the "most widespread conceptualization of the mechanism of human cognition" (Port, 2000, p. 5). This view in orthodox or "classical" cognitive science holds that intelligent action is a function of a physical symbol system (van Gelder, 1999). Cognitive function is conceptualized as the manipulation of symbolic representations of objects and experiences. The foundational metaphor is one of mind as machine (Thelen & Smith, 1994, p. 37) or computational (Kelso, 1995, p. 26). This view may have foundational roots in the 17th century as evidenced in the belief attributed to Thomas Hobbes, "Perhaps thought is symbolic computation, the rule-governed manipulation of symbols inside the head" (van Gelder, 1998, p. 1). The "best-known articulation" of this is "physical symbol system hypothesis" resulting from the work of Allen Newell and Herbert Simon in the 1970s (see overview Port, 2000, pp. 5-6; van Gelder, 1998, p. 1) which is also known as "law of qualitative structure" (van Gelder, 1999, p. 243). It lays out the principles of symbol manipulation accomplished in discreet time using the mathematics of abstract algebra for basic sequential operations. There has been significant scrutiny of the hypothesis of brain as computational machine resulting in near-consensus (see van Gelder, 1998, p. 5 for specific references).

Dynamical Hypothesis. There is a alternative to CH that is growing in popularity[10]: Dynamical Hypothesis (DH) (see, e.g., Port, 2000; van Gelder, 1998). It claims that cognitive agents are dynamical systems. Rather than cognitive symbol manipulation as in CH, dynamicists relative to DH believe that cognition is carried out by continuous quantities themselves governed by mathematical equations. Kelso argues that the brain is “fundamentally a pattern-forming, self-organizing system governed by nonlinear dynamical laws” (1995, p. 26). An example is that of limb movement. The Haken-Kelso-Bunz or “HKB” Model employs the mathematics of dynamical systems to research cognitive function associated with physical movement (see, e.g., Kelso, 1995, pp. 54-60 for description of the Haken-Kelso-Bunz Model). These researchers have found that finger wagging can be described and predicted, the relative phase of which is governed by a simple different equation[9]. As explained by van Gelder, Kelso’s work and similar research suggests that physical coordination governed by cognitive action is the “…emergent property of a nonlinear dynamical system self-organizing around instabilities. These models purport to provide the best available empirical accounts of phenomena in their domains” (1998, p. 4).

Comparison. As can be seen in Table 2 the views held by dynamicists for the Dynamical Hypothesis and those of computationalists or classicists for the Computational Hypothesis differ in at least six dimensions.

Table 2. Comparison of DH and CH (adapted from van Gelder, 1998, pp. 12-13)

System	**Dynamicists**	**Computationalists**
Focus	How things change	States of things
Conceptualization	Geometrical position	Internal structure
Structure in Time	Laid out temporally	Laid out statically
Behavior	How it happens	What it is
Operation	Parallel, on-going	Serial, I/O (in/out)
Interaction	Shape of change	Setting state

Basis. While developmental psychologists' deal with the psychological phenomenon of functional relationships (Goldhaber, 2000, p. 1), the underlying causative mechanism of neurological realignment (Cozolino, 2002) remains primarily aligned with classic principles such as reductionism philosophy (see, e.g., Shaw & McEachern, 2001b). However, neurological realignment may be dependent upon "new sciences" such as quantum mechanics and chaos or dynamical systems theory. As Gleick suggests of chaos theorists, "they are turning back a trend in science toward reductionism, the analysis of systems in terms of their constituent parts" (Gleick, 1987, p. 5). There is significant work in this area (for expanded discussion see, e.g., Schwartz & Begley, 2002; Schwartz & Beyette, 1996; Stapp, 1993).

Neuroscience does encourage including "knowledge of the brain in your overall understanding of human growth and development" (Cozolino, 2002, p. xvi). Cozolino contends that "early interpersonal environment may be imprinted in the human brain by shaping the child's neural networks and establishing the biochemical setpoints for circuitry dedicated to memory, emotion, and attachment" (2002, p. 13). If a mental patient improves, students learn, or there is human development by definition there has been change (Cozolino, 2002). If there has been change, at an atomic level quantum mechanics suggests that a probability wave has collapsed to effect brain changes, including new neural connections (Schwartz & Begley, 2002, p. 15), axon growth (Kolb & Whishaw, 1996, p. 69), increase of dendrite receptors via "second messengers" (Kolb & Whishaw, 1996, p. 89), increased synaptic efficacy and new anatomical connections (Tinazzi, Testoni, & Volpato, 1998), increased central benzodiazepine receptor densities in various subnuclei of the amygdala, and permanent increase in concentrations in concentrations of receptors for glucocorticoids in both the hippocampus and the PFC (Davidson, 2000). Kolb (1996, p. 499) holds that this post-natal brain-growth coincides with Piaget's four developmental periods (for expanded discussion of the four periods, see, e.g., Goldhaber, 2000, pp. 191-193). Current neurological research and the recognition of the brains ability to physiologically change[12] may be attempting to reconcile with foundational work in human development (for overview of neuroplasticity, see, e.g., Kolb, 1995; Schwartz & Begley, 2002; Shaw & McEachern, 2001b). It appears, then, that the primary association in neuroscience relative to human development, to this point, remains with the classic theories and not, as seems rational by current research to that of dynamic systems as primary causal factor in neurological alignment (Kelso, 1995; Thelen & Smith, 1994). As an example, while Thelen and Smith (1994) claim a "distinct Piagetian flavor" to their developmental view in that it gives primacy to active perception and movement and of the system to "self-equibrate" (see also Goertzel, 1995, p. 176), they hold significant difference from Piaget on other aspects of development. Most notably of these difference is Thelen and Smith's view expressing the dominance of mental activity as a dynamic assembly rather than that held by Piaget of a hierarchy of structure and mental activity as selection and not construction (1994, p. 130). She claims that there are "serious challenges" to the foundational claims of Piagetian theory: 1) an impoverished beginning state, 2) global discontinuities in cognition across stages, and 3) monolithic cognitive growth (for expanded discussion see, 1994, p. 22). Thelen and Smith argue well the position they and other dynamicists hold relative to the primacy of dynamical hypothesis in human development:

> … current theorizing in action and cognition lacked a principled basis for understanding development process. Many of the major theoretical systems, maturationist, neurological, rationalist-nativists, and information processing, have a teleological core. This core presumes an end-state before the development process begins and thus, in the words of Prigogine and Stengers (1984), negates the "arrow of time" (p. 16). At best, these approaches freeze development as a series of stagelike end-states, which do indeed capture the broad sweep of ontogeny. At worst, they are tautological and often vacuous: organisms develop because everything is getting better. Reductionist approaches describe the messy details, but leave the details without coherence. The questions of what develops and how it develops are unanswered (1994, p. 49).

Others are not so severe in their critique. As suggested by Goertzel (1995), while the breach between the dynamic system view and Piaget's developmental concepts may appear to be large, recent developments suggests that it is not so. He argues that the notion of psychological structure as fundamentally expressed in Piagetan concepts and that of the non-linear differential equation based thinking of dynamic systems theory may be bridged by evolutionary theory (1995, p. 176). As he suggests, "it gives an abstract model of mental process according to which representation schemes and self-organizing dynamics can coexist and interact" (1995, p. 176). Piaget's work may link the concepts of developmental psychology with those of mathematical, physical, and chemical dynamic systems. This metaphor of bridge seems appropriate in that the brain evolved in accordance with a specific scheme to adapt action and behavior, not to merely register representations (see, e.g., Kelso, 1995, p. 268). Too far abreast of the study presented here to be fully explored, some support Goertizel's assertion in that they believe that evolutionary psychology does not replace but is adjunct to other theoretical perspectives (see, e.g., Blasi, 2003). It is know that the evolutionary experience of the brain is unmatched, increasing by some five times its estimated original size (see, e.g., Kolb & Whishaw, 1996, p. 24). It seems, as previously mentioned, that such evolution had a distinct rationale: Adaptive behavior. There is a contemporary intertwined argument of neuroscience, classic developmental psychology and dynamic systems based cognitive development. It seems prudent if one is to understand human development then one must have a foundational understanding of the interrelationship of cognitive developmental psychology and dynamic systems.

Conceptualization: Chaos Overview

Background

Dealing with complex systems such as the brain, armed only with yesterday's theories, fostered a comfortable approach of elemental analysis; researchers look at isolated elements of the whole (reductionism, see Feynman, 2001; Fuchs, 1967). Understanding the whole operating in a nondeterministic environment in incomprehensible resultant patterns was too difficult. Theorists and practitioners of yesterday found unintended consequences of micro-level individual behavior leading to unexpected macro-social outcomes (Sawyer, 2003); they found, "doing the obvious thing does not produce the obvious, desired outcome" (Senge, 1990, p. 71). What was being evidenced was the "Butterfly Effect"[7] of chaos theory (see Gleick, 1987, pp. 9-

32). Also called “sensitive dependence on initial conditions” (Gleick, 1987, p. 8), the “Butterfly Effect” is a reference to a phenomenon in chaos theory where a small change to the input causes large changes to the output. Newtonian physics was being challenged (see, e.g., McElroy, 2004a, pp. 8-9; 2004b, pp. 5-7). The mathematical process of ‘iteration’ where feedback is reinitiated into a nonlinear system can lead to profoundly different outcomes given very similar inputs (Warren, Franklin, & Streeter, 1998. See also Figure 2). Further, it is ubiquitous (Gleick, 1987).

Chaos theory[11] arrived in the 20th Century (Sardar & Abrams, 1999) and is gradually taking the scientific establishment by storm (Vinten, 1992). This entry is characterized as be accompanied by varying degrees of denial and demoralization (Freeman, 1995). Twentieth Century science will be known for three things: relativity, quantum mechanics, and chaos (Gleick, 1987), with chaos the most notable (Sardar & Abrams, 1999). Some suggests that the study of chaos has its roots in mathematics and physics (Ditto & Munakata, 1995); however, Edward Lorenz, a meteorologists, discovered the phenomenon in his 1960s exploration of weather (see, e.g., Gleick, 1987, pp. 11-31) studying the interrelationship of three nonlinear meteorological factors: Temperature, pressure, and wind speed (Sardar & Abrams, 1999). His paper “*Deterministic Nonperiodic Flow*” is oft-cited relative to discussions of chaos. It mathematically described and graphically illustrated how nondeterministic behavior of a system becomes manifest with minor, previously considered irrelevant, system input changes.

Throughout the 1960s chaos was considered an “untested discipline” and not, therefore, well accepted. It failed to generate widespread interest and application (Eidelson, 1997). However, by the 1970s news about chaos came as an “electric shock” causing a “paradigm shift." Mathematicians, biologists, physicists, and chemists all contributed to chaos' development and, more important, its incorporation into academic research (see Table 3).

Table 3. Major contributions to the development of Chaos Theory

Year	Researcher	Contribution
1963	Edward Lorenz	His paper, "*Deterministic Nonperiodic Flow*" was first to describe chaos
1971	David Ruelle	Giving chaos theory a "kick-start" with research in turbulence, he also coined the term "strange attractor" in his paper, "*On the Nature of Turbulence*"
1975	Robert May	Working in population dynamics, contrary to Newtonian physics, discovered that nonlinear environmental feedback affected random changes in animal populations
1976	Mitchell Feigenbaum	First to prove that chaos is a universal property of nonlinear feedback systems
1977	Ilya Prigogine	1977 Nobel Prize: Dissipative structures. Author of oft sited book, *Order Out of Chaos* with Isabelle Stengers

James Yorke in 1975 gave the science its name in his paper "*Period Three Implies Chaos*" (Gleick, 1987, p. 69). Finally, emerging in the late 1980s (see, e.g., Gregersen & Sailer, 1993), there was general "academic diffusion" of chaos theory (Gleick, 1987). Today, some researchers encourage the "immediate and all-encompassing incorporation of the complexity sciences" including chaos theory into organizations (Wah, 1998), organizational analysis (Mathews, White, & Long, 1999), social work (Hudson, 2000), and social science (Gregersen & Sailer, 1993; Mathews et al., 1999). Especially pertinent to this paper is the recurring reference to chaos theory and understanding of psychology (Abraham & Gilgen, 1995; Kelso, 1995; Thelen & Smith, 1994) (see also Society for Chaos Theory in Psychology & Life Sciences and American Psychological Association Division 24 - Society for Theoretical and Philosophical Psychology, Appendix II). Some believe that the brain's basic organization is best described in accordance with chaos theory (Sardar & Abrams, 1999, p. 142). Others contend that the brain's activity may be chaotic (Ditto & Munakata, 1995), establishing psychological patterns such as brainwaves

(Gregersen & Sailer, 1993). As previously mentioned, it is argued that the brain is "fundamentally a pattern-forming, self-organizing system governed by nonlinear dynamical laws" (Kelso, 1995, p. 26). Psychologists are admonished to inform themselves about these current developments in analyzing complex systems such as the brain. If not, they will "be left behind" (Abraham & Gilgen, 1995, p. xvii). One reason for early "resistance" to chaos theory was the confusion with its basic definition (Eidelson, 1997). The problem remains today.

Theory

Chaos theory has not been adequately defined (Mathews et al., 1999) and, therefore, lacks a standard meaning (Ditto & Munakata, 1995). With confusion over chaos' concepts and definitions it is an "interdisciplinary 'Tower of Babel'" (Eidelson, 1997, p. 42). While Gleick admits that no one can quite agree on the definition of chaos, he nevertheless provides seven examples, including "… ubiquitous class of natural phenomenon," "… random recurrent behavior in a simple deterministic system," and "… systems liberated to randomly explore their every dynamical possibility" (1987, p. 306). As well, there is no general introductory text on chaos for the social scientists (Warren et al., 1998), while some have provided a premier for developmental psychologists (Kelso, 1995; Thelen & Smith, 1994). Chaos, or nonlinear theory in the social sciences is only now being developed.

"Where chaos begins, classical science stops" (Gleick, 1987, p. 3). Chaos theory, simply, is one taking a long-term behavioral consideration of systems. Its main characteristics is that aperiodic behavior[8] is found in mathematically simple systems and that these systems are sensitive to dependence on initial conditions (Sardar & Abrams, 1999). Chaos may be the theory that Lugwig von Bertalanffy asked for relative to General Systems Theory when he stated, "It seems legitimate to ask for a theory, not of systems of a more or less special kind, but of universal principles applying to systems in general" (Von Bertalanffy, 1969, p. 32). Chaos theory is applicable to systems across a wide array of disciplines, including management (Wah, 1998), organizations (Carroll & Burton, 2000), computers (Ditto & Munakata, 1995), behavioral and social science (Eidelson, 1997), biology, chemistry, economics, healthcare (Gleick, 1987) and psychology (Abraham & Gilgen, 1995; Kelso, 1995; Thelen & Smith, 1994). It is also applicable to a wide array of real world issues, such as weather, economic patters, laser beams, lung tissue morphology, heart rhythms, nerve impulse patterns, and neural network behavior (Thelen & Smith, 1994, p. 50). Scientist matured in their fields with reductionism, linear views of the world. Chaos deals with the occurring nonlinearity of nature with its attendant feedback. Feedback is "a characteristic of any system in which the output, or result, affects the input of the system" (Sardar & Abrams, 1999, p. 20). This is vividly demonstrated by the 1975 work of Robert May on fish populations. Using the logistics difference equation $x_{next} = rx(1-x)$, (see derivation, Gleick, 1987, p. 70), May incorporated two elements of feedback into his calculation of future fish populations. The variable "r", growth rate, is the time rate of change of an amount of substance and is proportional to the amount of substance present (Bronson, 2003):

$\therefore \frac{dN}{dt} - kN = 0$ where "k" is the constant of proportionality. Where varying sequential populations "feed back" on the base equation, in that they establish the next "current" population from which sequential calculation would be made, the growth rate, proportional to the population, would change.

The variable "x", the current population, is fed back as the nonlinear element (1-x), where "1" is the maximum theoretical fish population. This equation, in accordance with linear thinking, should provide a growing fish population up to an equilibrium value (see Figure 2). However, as Gleick (1987, p. 70) describes, this is not what happened:

> May increased the parameter as slowly as he could. If the parameter [“r”] was 2.7, then the population would be .6292. As the parameter rose, the final population rose slightly, too, making a line that rose slightly as it moved from left to right on the graph. Suddenly, though, as the parameter passed 3, the line broke in two. May’s imaginary fish population refused to settle down to a single valued, but oscillated between two points in alternating years.

Figure 2, representing growth profiles for “r” values of 1.7, 2.2, 2.7, and 3.7, clearly shows that with growth values under three (3) the population will rise at differing rates to differently levels of equilibrium. However, as seen in the growth rate of 3.7, the population “refused to settle down.” As May experienced, the values became chaotic and represented near-equivalency in alternating years. This is reflective of a fundamental concept of chaos: Aperiodic behavior is found in mathematically simple systems.

Mechanism: Means of Action

Principles

Thelen and Smith (1994), discarding elementary cause-and-effect concepts of cognitive action, characterize the “new science” as systems with a history, that change over time, where novelty can be created, where the end-state is not coded anywhere, and where behavior at the macrolevel can, in principle, be reconciled with behavior at the mircolevel (p. 49). It is the foundational work presented by Thelen and Smith upon which much of the following argument is based. Reiterating a speculation presented earlier, perhaps the “new science” that Thelen and Smith present is that which Bertanffy sought when he for asked for a “theory, not of systems of a more or less special kind, but of universal principles applying to systems in general" (Von Bertalanffy, 1969, p. 32).

Thelen and Smith present five fundamental standard beliefs that are held relative to dynamic system behavior in cognitive action (see parallel presentation, Kelso, 1995, pp. 5-15). These "global properties of complex systems" apply irrespective of their material substrates or, as they explain, at different levels of diversity and complexity with completely different constituent elements. They ask the central question, "How [can] complex systems, including developing humans, produce patterns that evolve in time?" (p. 51). Kelso refers to this as "the problem of complexity of substances" (1995, p. 5). These "patterns" are the mathematically expressed, graphically illustrated chaotic brain activity. Kelso goes on to ask another question relative to the complex action of the brain and the multi-functionality of our biological system (e.g., the mouth is used for both eating and speaking): How can a given pattern exist with changing environmental conditions (stability) and changing demands (adaptability)? He refers to this as "the problem of pattern complexity" (1995, p. 5). The five principles upon which the argument for dynamic systems are that systems (for expanded discussion, see Thelen & Smith, 1994, pp. 51-66):

1. are complex, operating far from thermal equilibrium;
2. exhibit self-organization;
3. seek dynamic stability and attractors;
4. change states via phase shifts;
5. change as a result of fluctuations to and transitions from its dominate behavioral mode.

Complexity and operating far from thermal equilibrium

Thelen and Smith argue that developing humans belong to a class of systems that are complex and exist far from thermal equilibrium. Harkening back five decades, Bertanaffy's General Systems Theory (GST) similarly stated that the basic systems problem is one of complexes of elements standing in interaction among themselves and the environment (see discussion Von Bertalanffy, 1969, p. 33; 1972, pp. 416-417). Of course, as previously mentioned, he sought a universal theory for these. Bertalanffy also recognized that self-maintaining systems are not provided for by ordinary laws of physics, specifically the 2nd law of thermodynamics[13]. Thelen and Smith, with their explanation of dynamic systems have, as a foundational starting point, the extensively studied and basic concepts expressed by GST and aspects of Complexity Theory (see Appendix III for similarity to Complexity Theory).

The brain itself is a compositionally complex system (see discussion Kelso, 1995, p. 5). The greater biological system survives via a process of coordination among the complex elements: Physical action requires the organization of such diverse sub-systems as the body's physiological, neurological, and cellular. The key condition by which this is accomplished is in the process of energy flow. Thelen and Smith explain, as Bertalanffy argued in the 1960s, that biological systems defy the second law of thermodynamics. Referencing Prigogine and Stengers (Prigogine & Stengers, 1984), they explain that dissipative structures maintain equilibrium by drawing energy from a high-energy potential, using it to do work, and then dissipating some the energy back into the environment. Systems, as Kelso explains (1995, p. 4), that are in a state of thermodynamic equilibrium are "as dead as anything can by." These "living" complex systems meet two criteria:

1. system components can interact in nonlinear and nonhomogeneous fashion;

2. in accordance with dissipative dynamics these systems exists far from thermodynamic equilibrium.

Self-organization

Self-organization is the most important subject in dynamics of psychology (Abraham, 1995). The "centerpiece" of Kelso's work (for full development, see 1995), as an example, is coordination or self-organization of dynamic patters. It reflects many others (see specifically, for e.g., Abraham & Gilgen, 1995; Thelen & Smith, 1994). Coming out of thermodynamics, self-organization is significantly dependent upon energy flow (Goerner, 1995). Goerner argues that "understanding nonlinear interdependence is key to understanding how and why systems structure themselves (1995, p. 4). This is the premise upon which Thelen and Smith continue to build the argument for cognitive dynamic systems.

They contend that self-organization develops as external conditions with sufficient energy drives a system from equilibrium. The resultant end state is, then, a drastically altered macroscopic state of the system. As Kelso defines, self-organization is "the spontaneous formation of pattern or pattern change that arise due to nonlinear interactions among the components of a system" (1995, p. 260). The self-organized end state is a function of the collective action of the individual elements until their behavior dominates and governs further behavior. This is supported by Kelso's research (1995). He explains that the coordination of the constituent parts of a system will, in turn, feed back and influence the behavior of the parts. Kelso refers to this as "circular causality" (1995, p. 10).

The "recipe" for self-organization contains four critical ingredients: The system is open, it is comprised of many components, it is nonlinear, and there is sufficient energy (see, e.g., Freeman, 1995, p. 27). The "circular causality," resulting in dominant behavioral modes, acts to constrain or compress the degrees of freedom within the system. The "order parameter" can act to "slave" or dominate other modes of behavior.

Kelso provides a cautionary note relative to self-organization (1995, p. 255-256). He believes that the concept of self-organization is occasionally being used as a "buzz word." It is misapplied. The term "self-organization" is being used to incorrectly classifying correlational patterns which are those changes to behavioral states which are accompanied by changes in cortical sites. They are not, however, manifestations of self-organization.

Dynamic stability and attractors

Brain activity seeks, what Thelen and Smith describe as, dynamic stability (see also, Kelso, 1995, pp. 54-60). Borne of the fundamental properties of the individual constituent elements and their collective drive to an order parameter (see previous section), the complex system of the brain will settle into one of a few behavioral modes. These modes or "attractor states" represent certain topology in state space (for detailed description of state space, see Abraham, 1995, pp. 32-35, also see Figure 3 for illustration) which are "an abstract construct of a space whose coordinates define the components of the system" (Thelen & Smith, 1994, p. 56). They are preferred modes which the system seeks given various but similar initial conditions. Thelen and Smith list the four characteristics of dynamic stability as:

1. the system seeks a preferred behavioral mode as a function of internal interactions and its sensitivity to external circumstances, what Kelso describes as the "basin of the attractor" (1995, p. 54). $Mode_{behavior} = f\left(Interaction_{internal} + Sensitivy_{external}\right)$,
2. the attractors have varying degrees of stability and instability,
3. some attractors seem so unstable as to be almost never seen while some are so stable as to appear inevitable,

4. systems may have two or more attractors, what Kelso describes as “multistability” (1995, p. 54).

While the system resides in dynamic stability, it does so coincidently in “dynamic instability” (see, e.g., Kelso, 1995, p. 22) This is an important perspective in that complex systems live near these areas of instability which gives rise to the enormous system diversity. It seems that the stability is then tenuous, always subject to bifurcations and change.

Phase shifts

A powerful challenge to earlier machine metaphors of the brain is that of phase shifts associated with dynamic systems. A change of state in a machine model, it is assumed, acts much like a computer logic circuit. States are determined by the activation of structural components. In dynamic systems, conversely, a control parameter can influence a system to abruptly jump to a new region within its state space. Such a “jump” constitutes a phase shift or transition (see Figure 3). The system, then, assumes a new behavioral pattern (see Figure 4). The pattern is determined by the energy and information which flows through the system (for expanded discussion, see Thelen & Smith, 1994, p. 63).

As can be seen in Figure 4, the system has to overcome restraining forces to move to a new phase. In effect, the system has to move up the wall of one phase before transcending down into the troth of another. Kelso questions this. In that the phase shifts require very little energy and are “informationally based,” he asks why a biological system “should have to climb over a barrier in order to switch states?” (see 1995, p. 156). The “effect” reflected in Kelso’s question is the phenomenon known in quantum mechanics as “tunneling” (for expanded discussion of the interrelationship of quantum mechanics and neurophysiology, see McElroy, 2004b), as depicted in Figure 5. In tunneling quantum particles appear to cross physical barriers with no signs of penetration or breach. They appear. Stapp (1993) argues that such a transition reflects a mental act, consciousness, causing a physical change, namely the collapse of the probability wave in which the quantum-level physical particles reside. In this sense, then, mind does have effect on matter. As Kelso states, referencing Stapp, “physical events in the brain and psychic events in the mental world are images of each other under a mathematical isomorphism” (1995, p. 157).

Fluctuations and transitions

The probability that a system will transition to a new behavioral state is determined by the relative variability around the mean state, what Kelso refers to as “dynamic instability” (1995, p. 22), and the time required to return to a stable state. Systems seek and maintain preferred states of behavioral patterns. However, they live enveloped in “noise” or variability and are, therefore, subject to being “pushed around” to new patterns. Kelso describes this as noise constantly “probing the system” [for influence opportunities] (1995, p. 16). Some argue that individuals have some element of control over this process within their own cognitive dynamical system (see, e.g., Abraham, 1995, pp. 46-47). Such an assertion suggests congruency between Schrodinger’s principles of quantum physics (see, e.g., Polkinghorne, 2002), Kolb’s (1995; 1996) theories on neuroplasticity and the brain’s ability to change, Stapp’s (1993) notions of the minds quantum mechanics explained influence on neurophysiological matter, Kelso’s (1995) chaos theory centered concepts of dynamic patterns in the brain, and Thelen and Smith’s (1994) dynamic systems theory of cognitive development (see Figure 6).

The sequential actions resulting in transitions are explained by Thelen and Smith (1994, pp. 63-66) (and graphically displayed in Figure 4) as:

1. The system resides in a preferred state;

2. At a “critical point” where pattern-influencing noise reaches a threshold level, the system can no longer maintain its behavioral pattern;
3. The system becomes dominated by fluctuations;
4. The system exhibits transient behavior where no stable pattern can be discerned;
5. The system moves to a new behavioral state as a function of collective variables acting on the system;
6. Fluctuations in the system are reduced and the system stabilizes into a new attractor state.

Applied

Strategic Intervention: Developing in chaos, a model for change

Introduction

As previously mentioned, individuals are theorized to have some element of control over this process within their own cognitive dynamical system (see, e.g., Abraham, 1995, pp. 46-47). As previously investigated (McElroy, 2004b), psychotherapy is therapist-facilitated focused mental effort bringing about brain changes and, thus, relief of psychological symptoms (Cozolino, 2002). These statements follow recent research that proves that the brain has the ability to physiologically change. It is now accepted that the adult brain can change, or exhibit neuroplasticity (Cozolino, 2002; Kolb, 1995; Satinover, 2001; Schwartz & Begley, 2002; Schwartz & Beyette, 1996; Stapp, 1993). Neuroplasticity is a fundamental property of neurons and the nervous system (Shaw & McEachern, 2001a). Researchers content that it is manifest in the ability of neurons to change the way they behave and relate to each other (Cozolino, 2002) and make new connections (Schwartz & Begley, 2002) including the process of dendritic arborization (Kolb, 1995;, 2003; Kolb & Whishaw, 1996). Some researchers suggest that neuroplasticity includes synaptogenesis (Manji, Quiroz, & Gould, 2003) and increased synaptic remodeling, efficacy and new synaptic connections (Manji et al., 2003; Tinazzi et al., 1998). Further, some believe that it includes an increase in the number of neural receptors and the activity of postsynaptic channels (Kolb, 2003), and enhanced long-term potentiation (LTP) (Manji et al., 2003). The brain, then, can rewire. Such altered electro-chemical changes in the brain may give rise to the ability to dynamically form new brain patterns and, thus, behavior.

Significant research in obsessive compulsive disorder (OCD) demonstrates the practical application of the underlying foundational theories of Stapp (1993), Kelso (1995) and Thelen and

Smith's (1994) (see, e.g., Schwartz & Begley, 2002; Schwartz & Beyette, 1996). Other disorders are being examined relative to these theories, such as post-traumatic stress (Department of Defense, 2003), brain injury (E. Katz, Victor, & Purpura, 1995; Kolb, Gibb, & Gonzalez, 2000; Robertson & Murre, 1999), alzheimer's disease (Neill, 2001), emotional distress (Davidson, Jackson, & Kalin, 2000), and mood disorders (Manji et al., 2003). For scholar-practitioners interested in the cognitive development of workers within organizational settings undergoing change, it seems appropriate to build on the foundational research in such psychological dimensions as those just mentioned.

Hypothesis

Macroscopic behavior (individual, group, organization, and social) is a function of microscopic systems dynamics (consciousness, belief system, supporting neural networks, brain activity, and cognitive patterns). Fundamental change, then, is not a function of forced behavior modification, but rather facilitated cognitive realignment.

IF leaders are tasked with assuming new roles and responsibilities coincident with organizational change, and, as with change in psychotherapy, theses new responsibilities require learning entailing physiological changes to the brain,

THEN the leader will foundationally and foremost be challenged to change cognitive patterns toward those more inline with and congruent of these new roles.

The Development Question

By what mechanism can complementary psychological changes be effected in leaders facing large-scale organizational change?

The Developmental Task

Developmental theories incorporating new concepts of cognitive dynamic systems is only recently being explored (see, e.g., Kelso, 1995; Thelen & Smith, 1994). Researchers in this field, dedicating significant attention on the perception-motor behavior interface call for expanded research. That is my intent. I am curious how such phenomenon can be harnessed to facilitate the modification of leader cognition and, then, beliefs relative to their organizational role. My up-coming research will explore this. In the interim, I believe it important to broach the foundational theories and the conceptual direction this research will pursue. I have, therefore, developed a fundamental seminar for such use.

Application: Cognitive Development, Harnessing Dynamic System Psychology

Different mechanisms are being explored to facilitate brain changes. These include exercise (Gomez-Pinilla, Ying, Roy, Molteni, & Edgerton, 2002), learning (Edeline, Pham, & Weinberger, 1993), therapy (Ruud, 1998), chemical (L. C. Katz & McAllister, 1999; Schuman, 1997), and brain stimulation (Lozano, 2001). Recent research in dynamic patterns in the brain suggests that various visual stimuli can induce changes to visual perception (Hock, Kelso, & Schoner, 1993), sound stimuli, similarly, on motor control (Jirsa & Kelso, 2005) and speech perception (Tuller, Case, Ding, & Kelso, 1994). Frederick Abraham (1995) suggests that the change mechanism will include:

1. Specification of a new initial condition,
2. Building into the system features that enable phase shift,
3. Foster simulated annealing by learning.

This is supported by Kelso and colleagues in a number of research projects which high-light the change mechanism for dynamic systems is dependant upon:

1. The direction of change (i.e., specify initial conditions) (Hock et al., 1993; Tuller et al., 1994),
2. The rate of change (Hock et al., 1993),
3. Repetition of (Tuller et al., 1994) or practice in (Kelso & Zanone, 2002) (i.e., learning),
4. Restricting the degrees of freedom (Fink, Kelso, Jirsa, & Guzman, 2000; Kay, Saltzman, Kelso, & Schoner, 1987) (i.e., building in system features which promote phase shift).

Developmental Challenge: The organizational leader in chaos

See PowerPoint presentation.

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Appendices

Appendix I

Quantum Mechanics (McElroy, 2004b)
Left unchallenged for over 200 years (Or, as some suggest, neglected. See Stapp, 2003a), classic or Newtonian physics continues to hold a revered place in scientific belief. This includes neuroscience. Many contemporary works in neuroscience and related fields ascribe to this traditional system, citing "ordinary laws of physics" (see general discussion Schwartz & Begley, 2002, pp. 260-261), as that solely employed in brain processes (see Benson, 1998; Kalat, 1993; Kolb & Whishaw, 1996; Sonderegger, 1998). For example, these works do not broach the basic quantum principles underlying many of the fundamental brain processes of neuron activation or "firing" (Stapp, 2001). Stapp explains that "brain processes depend critically upon synaptic processes, which depend critically upon ionic processes that are highly dependent upon their quantum nature" (2001). William James' late 19th century views on mind-brain interaction, consistent with contemporary interpretation of quantum theory, is "eerie" (Schwartz & Begley, 2002). Common descriptions of brain functions tend to be provided in traditional terms of mechanical determinism of particles (*e.g.,* neurons release a chemical that either excites or inhibits the next neuron, action potentials reach the terminal button causing the release of neurotransmitter molecules, calcium channels are opened in the synaptic membrane when an action potential reaches the synapse).

Founder of our classic system of physics, Isaac Newton is, of course, venerated. Newton saw things that no other person had seen (Walker, 2000). Modern physics reached its culmination with Newton's 1687 book *Principia* which described, as Polkinghorne explains, "motions of particles in ways that were clean and deterministic" (2002, p. 1). His 17th century work was elevated to the position of an "imposing theoretical edifice" (Polkinghorne, 2002, p. 4). Today, with some humor and, one may assume, equal embarrassment with the voiced naiveté of the past, the scientific community recalls many early "celebrated assertions" attesting to this. By the end of the 18th century, there were reverent decrees that "a being, equipped with unlimited calculating powers and given complete knowledge of the disposition of all particles at some instant in time, could use Newton's equations to predict the future, and to retrodict with equal certainty the past" (Polkinghorne, 2002, p. 1). By the end of the 19th century some believed that "all the big ideas of physics were now known and all that remained to do was tidy up the details with increased accuracy" (Polkinghorne, 2002, p. 4), left only to fill in the sixth decimal place (McEvoy & Zarate, 1996). And in the last half of the 20th many continued to believe that physics is a "science of experience" and "differs in no way from the classic physics which was… magnificently developed by Isaac Newton" (Fuchs, 1967, p. 94).

However, cracks started to appear in the edifice of Newtonian physics in the first quarter of the 20th century. It has widened into an irreconcilable chasm until, today, we have the classic view that *explains* everyday experiences and quantum mechanics that – with current knowledge – can only *describe* how the universe works. After all, "… nobody understands quantum mechanics" (Feynman, 2001, p. 129); quantum mechanics cannot be explained, only described (Feynman, 2001, p. 130; Polkinghorne, 2002, p. 22). There has evolved, then, a cataclysmic break from classic physics.

Break from Classic Physics
Even in Newton's time scientist recognized that he did not "embrace all aspects of the physical world that were then known" (Polkinghorne, 2002, p. 1). Issues left unaddressed included the nature of the universal inverse-square law of gravity. Issues which received only speculative conjecture from Newton included the particle nature of light (later discovered to exhibit wave properties, as well). These unsettled issues, even in the late 17th century, "threatened belief in the self-sufficiency of the Newtonian synthesis" (Polkinghorne, 2002, p. 1). While Newton's achievements were "imposing," they left unanswered questions and, more important, clearly indicated that his fundamental premise of the mechanical nature of reality was incorrect. This view simply did not allow for an understanding of conscious experience.

However, Newton was to rise to wide acceptance, heralded as "the greatest genius in the history of physics" (Fuchs, 1967, p. 191). No significant challenges to Newtonian physics occurred for nearly 200 years (from his 1687 publication of *Principia*). However, beginning in 1885 occurred in a 38-year period six major findings which questioned the foundational concepts of classical physics. Each drove a wedge deeper into the structure of this system. The continued findings which contradict Newton's early assumption include contemporary concepts subsumed under quantum theory.

Appendix II

Society for Chaos Theory in Psychology & Life Sciences

http://www.societyforchaostheory.org,

Purpose of the Society

The Society is an international forum bringing together researchers, theoreticians, and practitioners interested in applying dynamical systems theory, far-from-equilibrium thermodynamics, self-organization, neural nets, fractals cellular automata, and related forms of chaos, catastrophes, bifurcations, nonlinear dynamics, and complexity theories to psychology and the life sciences.

Our members hail from numerous specialties within psychology and the social sciences as well as from biology, physiology, neuroscience, mathematics, philosophy, physics, computer science, economics, education, management, political science, engineering, and the world of art. As of August 2003 we have 310 members in 33 countries.

Division 24 - Society for Theoretical and Philosophical Psychology a Division of the American Psychological Association

http://www.apa.org/about/division/div24.html
http://soe.indstate.edu/div24/WhatisDivision24.htm

Division 24 of the American Psychological Association is the division of Theory & Philosophy. This division is a very eclectic division, with members from many specialty areas of interest. The common interest among this diverse group is the philosophy of psychology and the social sciences, as well as the social foundations of psychology.

Some of the diverse areas of interest are:

- The philosophy of science and psychology
- The influence of cognitive neuroscience and biological psychology on psychology's image of human beings
- The place of ethical concerns in psychology
- The place of spirituality in psychology
- The effects of managed mental health care on psychotherapeutic practice
- The role of qualitative methods in psychology, including phenomenology, cultural psychology, narrative, and discourse analysis
- Feminist and postmodernist perspectives on psychological knowledge

Appendix III

Complexity Theory (McElroy, 2004a, pp. 26-27)

One of the “new sciences” becoming a popular framework for organizational analysis is complexity theory (Adler, Black, & Loveland, 2003). Where chaos is the “science of process” (Gleick, 1987) primarily dealing with situations (circumstance or condition such as turbulence), complexity deals with systems (organization or arrangement) “composed of many interacting agents” (Axelrod & Cohen, 2000, p. xv). Complexity theory is the study of behavior of macroscopic collections of units that are endowed with the potential to evolve over time (Murray, 1998).

However, complexity theory is not an independent supposition of isolated phenomenon, but a eclectic notion encouraging the incorporation of all the “complexity sciences” (Mathews et al., 1999). “Complexity theory,” then, includes nonlinear dynamic systems theory, non-equilibrium thermodynamics, dissipative structures, the theory of self-organization, catastrophe theory, the theory of self-organized criticality, antichaos, and chaos theory (Mathews et al., 1999). How these various theories comprehensively work together to form universal principles of organizational dynamics is only generally conceived. The fundamental concepts of this science are young and evolving. Considered across many levels of abstraction, described variously as “structure” (Axelrod & Cohen, 2000; Okes, 2003), “dynamics” (Eidelson, 1997), and “principles” (Murray, 1998), authors site similar constituent aspects of complexity theory. Critical to the notion seem to be the primary aspects of:

1. Distributed control (Eidelson, 1997; limited, see Okes, 2003; no central control, see Wah, 1998);
2. Robust feedback (shorter-term, finer-grained measures, see Axelrod & Cohen, 2000; flexible and redundant, see Eidelson, 1997; sufficient with multiple sources, see Okes, 2003; non-linear, see Wah, 1998);
3. Strong linkage/network (reciprocal interaction, see Axelrod & Cohen, 2000; absolute number and strength/frequency, see Eidelson, 1997);
4. Small changes (tiny perturbations, see Ditto & Munakata, 1995; Okes, 2003).

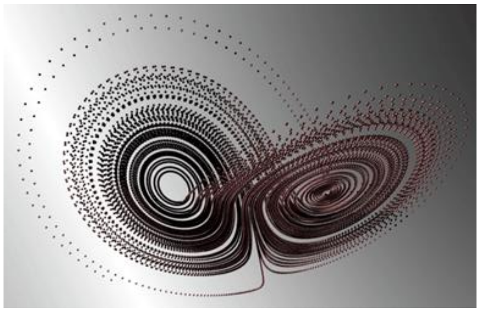
Footnotes

1. *Behaviorism*. John Watson (1878-1958) had a radical break with classical experimental psychology. He launched his school of psychology in 1913 centered on the prediction and control of behavior. Watson believed that behavior is a product of learning and learning consists of conditioning (see Dictionary, 2003, pp. 83-84). Behaviorists believe that "A self or personality is at best a repertoire of behavior imparted by an organized set of contingencies… genetic endowment is nothing until it has been exposed to the environment, and the exposure immediately changes it" (Skinner, 1974, p. 149-150). Personality is then a function of environmental experiences.
2. *Newtonian physics* - the system of physics based principally on the dynamics of Isaac Newton, 1642-1727 (including his famous law of gravitation). The system was very successful in predicting the behavior of particles, pendulums, machines etc up to the end of the 19th Century when the new physics began to have its impact.
3. By the principles of classic physics and Rene Descartes' concept man is but a mechanical automaton (Stapp, 2001). Rejected by many philosophers (Hospers, 1967; Stapp, 2003a), this notion is a logical extension of the classic view suggesting a purely material world. It holds that tiny "mindless" particles, acting much like billiard balls, react with each other void of man's conscious intervention. Acts are, then, fixed by physically described conditions and controlled by mechanical laws. Western science has made "unbridgeable" the divide between the world of mind and that of matter. This includes the foundational building blocks of the brain (*e.g.*, ions) and, thus, the consequential processes of the brain (Stapp, 1993;, 2001;, 2003b).

4. *Systems and Systems Theory*. There are many definitions for systems. Bertalanffy defined it as “complexes of elements standing in interaction” (1969, p. 33) and, in later works expanding the interaction to include the environment, “a set of elements standing in interrelation among themselves and with the environment” (1972, p. 417). Some define systems more broadly. As Weiss suggests, a system is “anything unitary enough to deserve a name,” and Boulding as, “anything that is not chaos” (Skyttner, 1996). Most, however, subscribe to Bertalanffy’s basic definition. Miller defines system as “a set of interacting units with interrelationships among them,” Parsons as “a general or fundamental property of interdependence of parts or variables,” and Hall and Fagen as “a set of objects together with relationships between the objects and between their attributes” (Bailey, 1994). Kenneth Bailey, founder of Social Entropy Theory, suggests that there are distinct similarities in the various definitions of system (Bailey, 1994). They are:
   - Specify some basic units of the system;
   - Specify connections;
   - Specify or imply that relationships are nonrandom;
   - Allow the existence of boundary;
   - Allow or presume existence of environment outside of the boundary.
5. *Humanistic psychology*. Humanistic psychology proposes that “personality depends on what people believe and how they perceive the world” (Kalat, 1993, p. 549). A more contemporary, accepted view of personality development, humanistic psychology “was influenced by existentialism and phenomenology, stressing individual free will, responsibility, and self-actualization” (Dictionary, 2003, p. 340). They believe that

personality is “the relatively enduring pattern of recurrent interpersonal situations which characterize a human life” (Valle & Halling, 1989, p. 182). Valle and Halling contend that human behavior has to be interpreted within context and not as events, “psychiatry is the study of interpersonal relations and not the study of personality *per se*” (1989, p. 182). Two champions of the humanistic psychology movement were Carl Rogers and Abraham Maslow.

6. Aristotle taught “the whole is more than the sum of its parts” (see, e.g., Allen, 1985, pp. 413-432, section "Physics").



7. The “Butterfly Effect” is the notion that a butterfly stirring the air today in Brazil can transform storm systems next month in Texas (Gleick, 1987, pp. 9-32). It is named from the work of Edward Lorenz, who’s 1972 paper “*Does the Flap of a Butterfly’s Wings in Brazil Set Off a Tornado in Texas?”* and the “strange attractor” he identified as part of his work with the first chaotic system resembling a butterfly (see graph) contributed to the butterfly winds as an enduring emblem of chaos.
8. Aperiodic behavior occurs when no variable affecting the state of the system undergoes a completely regular repetition of values.
9. The basic Haken-Kelso-Bunz equation: $\phi = -a\sin\phi - 2b\sin 2\phi$, where ϕ is a single “collective” state variable of the system. This model has been applied in various cognitive fields (for full explanation of HKB model, see Kelso, 1995, pp. 54-60; for expanded discussion and list of fields, see van Gelder, 1998, pp. 3-4).

10. van Gelder (1998) in supporting his claim of "gaining momentum" for the dynamical hypothesis provides examples of its central position in specific research projects. As displayed in the below table, statistically analyzing these references reveals, as van Gelder suggests, an increase in DH reference in published articles and studies.

Table 4. Growing Reference to Dynamical Hypothesis in Research

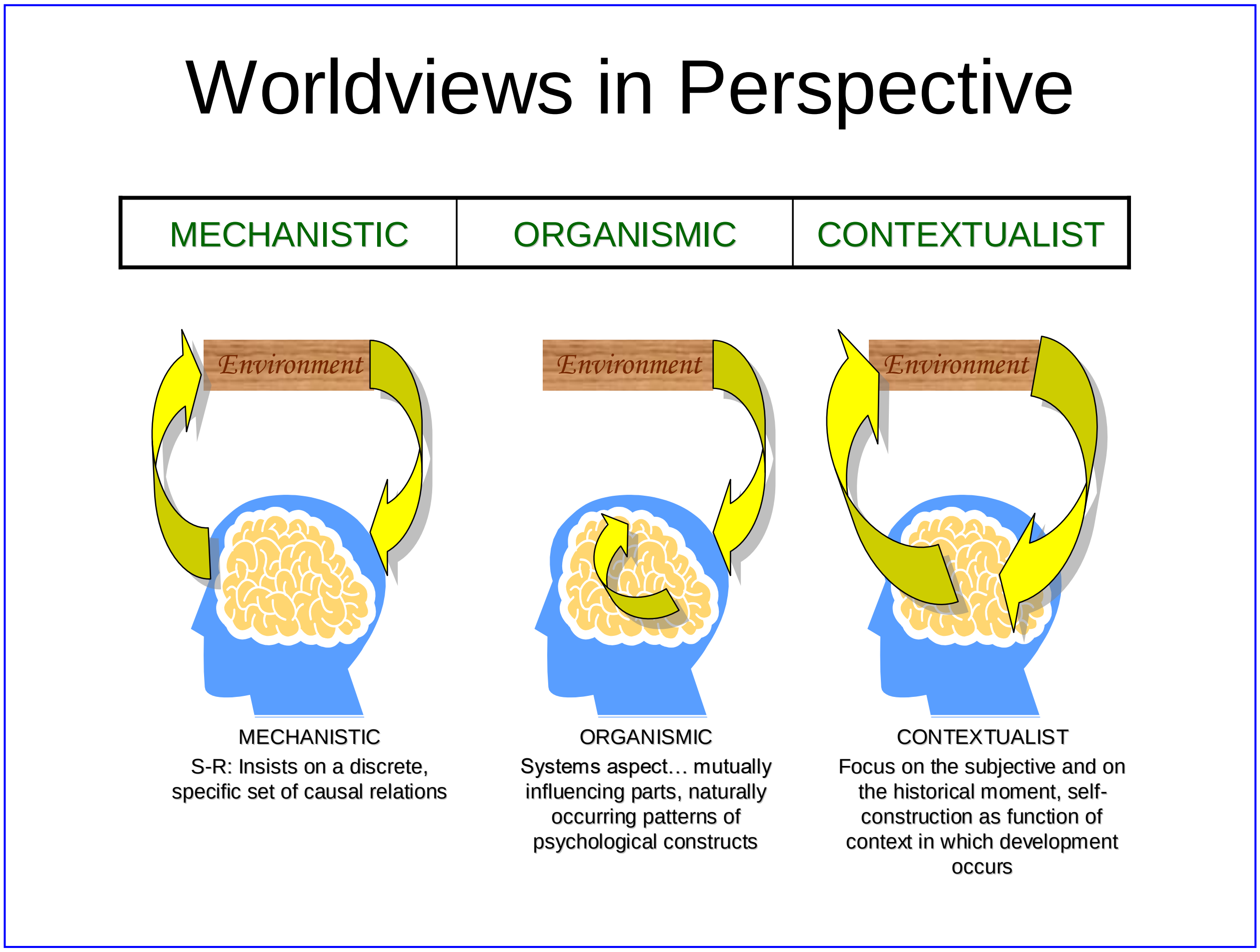
Period	**Articles/Year**	**Percent Change**
1980-1984	1.4	
1985-1989	1.4	0.0%
1990-1992	2.0	43%
1993-1996	4.3	136%

11. The new science often referred to as chaos theory is also variously called the study of dynamic, synergetic, dissipative, nonlinear, self-organizing systems (Thelen & Smith, 1994, p. 50).
12. I recently explored the current research in the brain's plasticity, documented in my essay *Quantum Mechanics and Neuroplasticity: An Elementary Examination of the Interrelationship* (McElroy, 2004b).
13. I recently touched on the contradictory notion of self-maintaining systems and operation far from thermal equilibrium while researching systems theory (McElroy, 2004a). I learned that self-maintaining systems are not provided for by ordinary laws of physics, specifically the 2nd law of thermodynamics (Von Bertalanffy, 1969). This law states that "ordered systems in which irreversible processes take place tend toward most probable states and, hence, toward destruction of existing order and ultimate decay" (Von Bertalanffy, 1972, p. 409), toward maximum entropy and disorder (Bailey, 1994, p. 148).

However, Bertalanffy argues that the “order of a whole… is a fact of observation” (1972, p. 408). Systems, in fact, do not naturally move toward total destruction. Thus the dilemma: How could the organizational complexity that clearly existed in living systems be explained without contradicting the second law (Bailey, 1994)?

Figures

Figure 1, Worldviews in Perspective depicting three schemes relative to interrelationship of environment and mental operation



Worldviews in Perspective

MECHANISTIC	ORGANISMIC	CONTEXTUALIST

MECHANISTIC
S-R: Insists on a discrete, specific set of causal relations

ORGANISMIC
Systems aspect… mutually influencing parts, naturally occurring patterns of psychological constructs

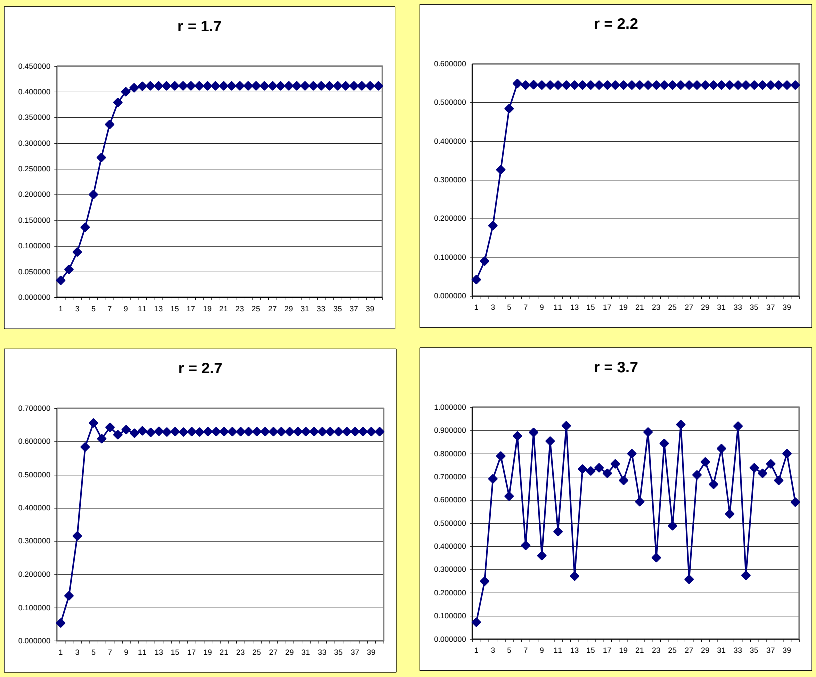
CONTEXTUALIST
Focus on the subjective and on the historical moment, self-construction as function of context in which development occurs

Figure 2, Logistics Difference Equation: Increasing growth rates until the onset of chaos.

$x_n = rx(1-x)$ Logistics Difference Equation

0.02 = x

1.7	**2.2**	**2.7**	**3.7**	= r
0.033320	0.043120	0.052920	0.072520	
0.054757	0.090773	0.135323	0.248865	
0.087989	0.181574	0.315928	0.691646	
0.136420	0.326931	0.583517	0.789106	
0.200276	0.484103	0.656167	0.615745	
0.272282	0.549444	0.609152	0.875431	
0.336845	0.544622	0.642832	0.403491	
0.379747	0.545620	0.619917	0.890538	
0.400417	0.545421	0.636173	0.360676	
0.408141	0.545461	0.624933	0.853179	
0.410655	0.545453	0.632857	0.463479	
0.411430	0.545455	0.627342	0.920065	
0.411664	0.545454	0.631217	0.272118	
0.411734	0.545455	0.628512	0.732858	
0.411756	0.545455	0.630409	0.724375	
0.411762	0.545455	0.629083	0.738726	
0.411764	0.545455	0.630012	0.714136	
0.411764	0.545455	0.629362	0.755340	
0.411765	0.545455	0.629817	0.683766	
0.411765	0.545455	0.629498	0.800051	
0.411765	0.545455	0.629721	0.591886	
0.411765	0.545455	0.629565	0.893761	
0.411765	0.545455	0.629675	0.351324	
0.411765	0.545455	0.629598	0.843214	
0.411765	0.545455	0.629652	0.489157	
0.411765	0.545455	0.629614	0.924565	
0.411765	0.545455	0.629640	0.258055	
0.411765	0.545455	0.629622	0.708412	
0.411765	0.545455	0.629635	0.764289	
0.411765	0.545455	0.629626	0.666560	
0.411765	0.545455	0.629632	0.822354	
0.411765	0.545455	0.629628	0.540526	
0.411765	0.545455	0.629631	0.918923	
0.411765	0.545455	0.629629	0.275662	
0.411765	0.545455	0.629630	0.738789	
0.411765	0.545455	0.629629	0.714026	
0.411765	0.545455	0.629630	0.755514	
0.411765	0.545455	0.629629	0.683437	
0.411765	0.545455	0.629630	0.800499	
0.411765	0.545455	0.629630	0.590892	



r = 1.7

r = 2.2

r = 2.7

r = 3.7

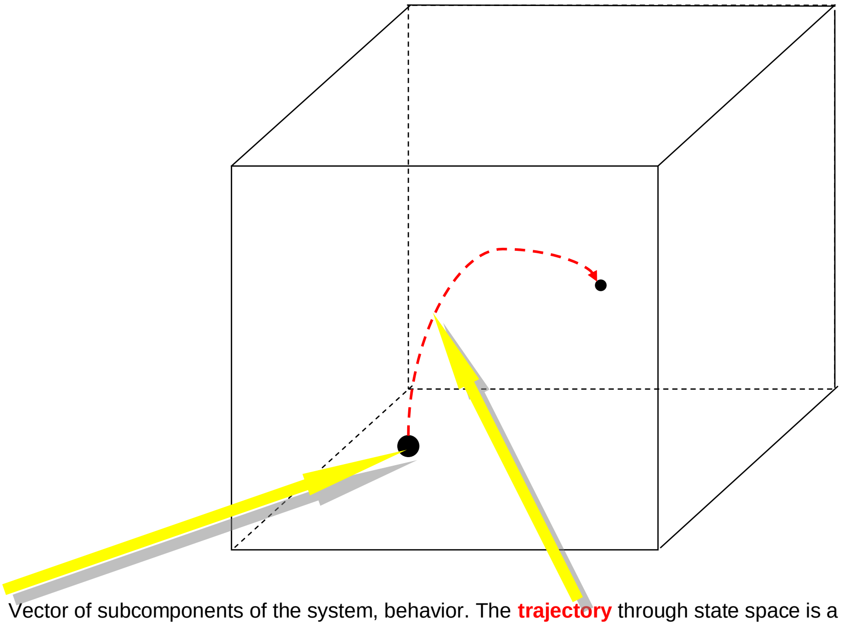
References:
(Gleick, 1987, pp. 61-65, 69-71; Sardar & Abrams, 1999, pp. 18-21)
Gleick, J. (1987). *Chaos: Making a New Science* . New York, NY: Penguin Books.
Sardar, Z., & Abrams, I. (1999). *Introducing Chaos* . New York, NY: Totem Books.

Figure 3, Graphical depiction of multi-dimensional state space

State Space

Non-equilibrium Systems: General Dynamic Equation

$$q = N(q, parameters, noise)$$



q: Vector of subcomponents of the system, behavior. The **trajectory** through state space is a nonlinear function of N of the vector.

Figure 4, Phase Shift

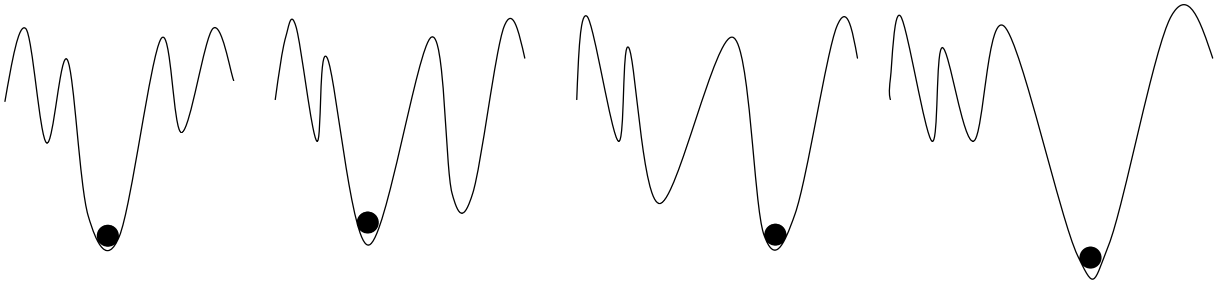


Figure 5, Tunneling

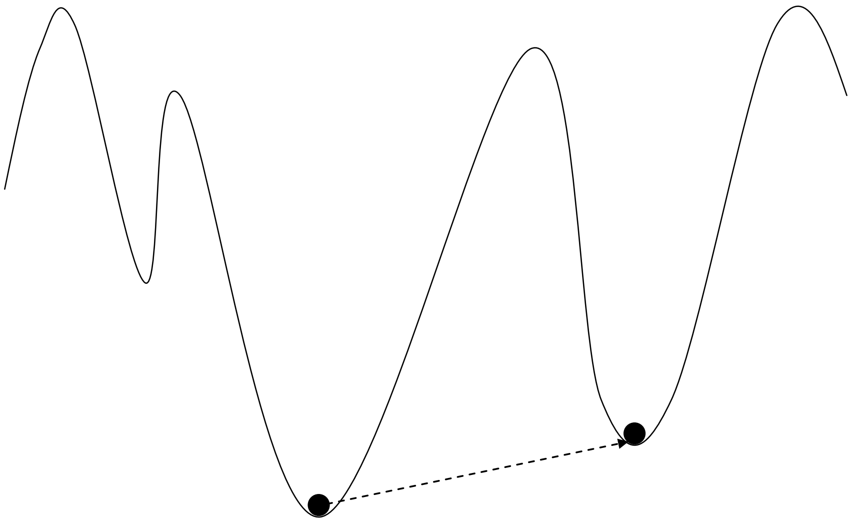


Figure 6, Interrelationship of Research Theories: The Quantum Brain