CHAPTER FOUR

Emergence: When a Difference in Degree Becomes a Difference in Kind

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Over the past fifteen years, psychoanalysts have become increasingly interested in the modeling techniques and implications of complexity theory. Complexity theory is based on the findings from several areas of research, including the study of nonlinear dynamic systems, deterministic chaos, self-organization, artificial life, and cellular automata, to name a few. Although these lines of research differ in terms of emphasis and technique, they share an interest in understanding the processes underlying emergence. Emergence describes the development in a dynamic system of collective and coordinated structures, functions, and patterns that are qualitatively different, irreducible, and unpredictable from knowledge of a system's preceding conditions.

Emergence may seem like a relatively uncommon occurrence, but once we begin to look, we see signs of emergence in a wide variety of systems. For instance, there is evidence of emergence in the evolution and extinction of species (Kauffman 1995) and in the history of the Earth's climate and geological changes (Bak 1996). There is also evidence of emergence in predator–prey relationships, the spotted or striped patterns of animal coats, and the collective, coordinated patterns of birds in flight, hiving bees, and foraging ants and termites (Goodwin 1994; Resnick 1994). Getting a little closer to home, there is evidence of emergence in organizational dynamics (Goldstein 1994), traffic patterns, the distribution of wealth in society, the spread of disease (Epstein and Axtell 1996; Resnick 1994), patterns of brain activity (Freeman 1995, chapter 2) and human development (Demos, chapter 6; Kelso 1999; Thelen and Smith 1996; Wolff 1996), motivation (Ghent 2002), gender identity

(Harris 2005) and psychic organization or structure (Goldstein, chapter 5). This represents just a partial list of the systems that have been examined through the lens of complexity theory. In this chapter, I suggest that symptoms are emergent, arising from the restrictive unconscious attitudes that characterize the way an individual organizes subjective experience. However, conceptualizing symptoms as emergent will not come for free. On the contrary, it will require revisiting some basic psychoanalytic assumptions about the mind.

Dedicating energy to arriving at yet another new model of the mind is not without its critics. In fact, the difficulties inherent in developing an adequate model of the mind have led some to reasonably conclude that the entire enterprise of modeling should be scrapped and replaced with a purely clinical theory. After all, models can often take on a rather experience-distant quality, even when the findings derived from the models appear to closely approximate the system of interest. This may be especially true of complexity theory with its use of abstract mathematic models. From my perspective, however, an appropriate model of the mind can sharpen and deepen our understanding of a system in unanticipated ways. For this reason, I agree with David Rapaport (1951) who writes, "The disagreements between model makers dwarf all their agreements—except one: that model making is necessary" (407).

As a way of framing much of what will follow, let me cite two ways in which the models used in complexity theory have influenced my thinking. First, they have led me to conclude that much of psychoanalytic theorizing is based on linear dynamics—dynamics that do not provide an account for genuine emergent phenomena. This may seem like a trivial point, but I think it may help explain why aspects of psychoanalytic theory have not been supported by empirical research. Second, and more importantly, the elegant simplicity and robustness of complexity theory's nonlinear models have led me to reconsider some basic psychoanalytic assumptions about the underlying structure, properties, and dynamics of the mind.

In previous work (Piers 2000, 2005), I have focused on chaotic systems and reviewed research that has utilized analytical techniques, such as difference and differential equations. Chaotic systems are a class of nonlinear systems that exhibit staggering variability, sensitivity, and adaptation in response to perturbations (in the form of sensitive dependence on initial conditions), while at the same time, an enduring and distinctive coherence and continuity in their overall organization (in the form of strange attractors). As such, I have found chaotic systems useful in conceptualizing how relatively healthy people remain recognizable, or "in character," in the midst of their variability, adaptation, and change.

Among the findings I found most striking in my study of chaotic systems was that with very little built into the design, nonlinear models generated extremely complicated and unanticipated behavior that resembled real-world systems. It was this observation that ultimately led me to research on cellular automata (CAs) because they are among the most parsimonious, robust, and readily accessible models in complexity theory. In this chapter, I review Stephen Wolfram's one-dimensional CAs, John Conway's well-known, two-dimensional CA known as the "Game of Life," and agent-based modeling techniques used to model social systems (Epstein and Axtell 1996; Resnick 1994). This will be followed by an effort to formulate psychological symptoms as emergent properties of unconscious, restrictive organizing attitudes.

Linear and Nonlinear Systems

Linear systems are systems that evolve in *continuous*, *proportional*, and *predictable* ways. The continuity of change in linear systems means that a system's current state can be readily traced to antecedent conditions. That is, when we observe the changing states of a linear system over time, there is a straight, unbroken line that links one state to the next, even states separated by significant periods of time. Therefore, linear dynamics allow us to arrive at all the possible states of the system through some combination and/or weighting of the identified component parts and forces acting in the system. Continuity of change is related to proportional change or the clear input–output relationship evident in linear systems. Proportional change means that the magnitude of a perturbation is equal to the resulting change we see in the system: minor perturbations having small effects, substantial perturbations having large effects. With all this said, linear systems are predictable. Armed with full knowledge of the current state of the system, we should be able to predict future states of the system at any point in time. None of this can be said of nonlinear systems. Indeed, a telltale sign of a nonlinear system is the presence of abrupt, discontinuous, nonproportional, and unpredictable transformation and change.

It is common for us to assume that there is continuity, proportionality, and predictability between cause and effect. This impression arises from several sources, including perhaps our need to see order and regularity. Among the sources, it should be appreciated that this impression is continuously reinforced by our daily experiences with human-made, mechanical systems, the vast majority of which are based on linear dynamics (Galatzer-Levy 2002). Moreover, we rely on mechanical systems to behave in linear ways. For instance, imagine the trouble that would ensue if we did not reliably know how much pressure to apply to the brake to bring a car to a gradual or sudden stop. While we want our cars to behave in linear ways, complexity theory suggests that linear dynamics fall short of explaining the changing states of many natural and biological systems.

Psychoanalytic Thought

The distinction between linear and nonlinear systems sets the stage for my main thesis. Psychoanalysis, with its emphasis on childhood conflicts of fixed mental content (memories, thoughts, fantasies, and mixtures thereof, along with associated affect), which are carried across time in relatively unmodified form and released under certain conditions, is a model of symptoms founded on linear dynamics. This should not be at all surprising. After all, most areas of science have traditionally turned to linear dynamics to understand systems. In this way, psychoanalysis is in respectable company, formulating its subject matter in ways consistent with the rest of science.

To substantiate my claim, let's return to the beginning with Freud's 1896 paper entitled "The Etiology of Hysteria." In this paper, Freud develops an archeological metaphor to describe the etiology of symptoms and the task of treatment. Freud sees the analyst as an archeological explorer whose "interest is aroused by ruins showing remains of walls, fragments of pillars and of tablets with obliterated and illegible inscriptions." Armed with "picks, shovels and spades" the analyst aims to "clear away the rubbish and, starting from the visible remains, may bring to light what is buried" (184–85). Linking the metaphor back to symptoms, Freud suggests that the analyst must "lead the patient's attention from the symptom back to the scene in and through which it originated; and having thus discovered it, we proceed when the traumatic scene is reproduced to correct the original psychical reaction to it and thus remove the symptom" (185).

Freud's formulation reveals the underlying linear dynamics of his thinking because it indicates that what the analyst is observing in the form of an adult symptom is the reappearance or resurfacing of an anachronistic reaction tied to an enduring traumatic scene embedded in the recesses of the mind. Nothing new or novel is emerging. Consistent with formulations based on linear dynamics, the symptom represents the "unfolding of what has already been enfolded" (Goldstein 2003).

Moving from symptoms to Freud's conceptualization of character, let's turn to his 1915 paper entitled "Some character types met within psychoanalytic work." To reveal the linear dynamics, let's examine Freud's formulation of "those wrecked by success." Freud explains that a person falls ill in the context of success because he is confronted with the fulfillment in reality of an unconscious, forbidden, and anachronistic wish arising from the Oedipus complex. Deeply threatened by the prospect of the wish being gratified, the person defends against its fulfillment by sabotaging his success. Here, the characterological problem—the wrecking of success—is tied directly to the activation of a preexisting and preserved wish in the context of a wish-specific environmental perturbation.

Remaining on the subject of character but following the introduction of structural theory, more evidence for the linearity in Freud's thinking can be seen in his 1931 discussion of "libidinal types." In this paper, Freud derived different character types based on the amount of libido allocated to the id, ego, and superego. The overallocation of the fixed amount of libido in one or two of the psychic agencies to the proportional diminishment of the other agencies served as the explanation of the pure and mixed types he described. In this model, normality was seen as the equal investment of libido in each of the three psychic agencies. This model is a linear one because it suggests that there is a smooth, gradual continuity between the different character types based upon the allocation of a fixed reservoir of libido.

Indeed, there are numerous psychoanalytic formulations founded on linear dynamics.

- The return of the repressed
- Developmental fixation, arrest, and deficit
- Regression
- Psychosis conceived of as the dissolution of defenses and a return to a earlier psychic organization
- Paranoia as an expression of an unconscious homosexual wish
- Anorexic food restriction as the result of an unconscious fantasy of oral impregnation

In each case, the particular adult symptom or psychic organization is tied directly, often in a fairly straightforward manner, to the resurfacing of something preexisting and enfolded in the mind.

Linear dynamics are not absent from contemporary theorizing either. Taking their lead from Freud's archeological metaphor, clinicians often attempt to uncover from the past an as-yet unrevealed trauma to explain a patient's catastrophic symptomatic picture. Such searches, which are often highly selective and biased, invariably turn up memories or fantasies from the patient's life history that bear a thematic affinity to the symptoms and/or the symptomatic relational patterns unfolding in the psychotherapy. This contemporary tendency reveals two linear assumptions. First, to explain a catastrophic picture requires the identification of a cause or perturbation of equal severity, and second, what we see now is simply the reappearance of something already available to the mind.

It is not that psychoanalysis has failed to appreciate the presence of emergent phenomena. As Galatzer-Levy (1978) points out, psychoanalysis has long grappled with discontinuities in both development and treatment. He suggests that in the absence of an adequate model, however, psychoanalysis has attempted to deal with these observations in problematic ways, several of which have already been mentioned. For example, Galatzer-Levy argues that, at times, psychoanalysis has:

- Dismissed emergent phenomena out of hand
- Linked discontinuous change to a perturbation or trauma of equal severity
- Attributed emergent phenomena to an unspecified biological cause outside the scope of psychoanalytic theorizing
- Frontloaded or posited the presence of structures in the initial or starting conditions of the mind, often in post hoc fashion, to account for emergent phenomena while leaving the underlying linear dynamics intact

All of these solutions can be seen as efforts to salvage linear dynamics. None of them are necessary, however, when the mind is conceived of as a nonlinear system with emergent properties.

The frontloading solution is particularly interesting because it may explain, in part, why some psychoanalytic developmental theories see infants and young children as possessing capacities and proclivities that are not supported by well-conducted developmental research (Eagle 1984; Westen 1990). Moreover, frontloading may account for the problematic way psychoanalytic theory has often equated pathological functioning to the way normal infants function, and the related assumption that pathology arises from the persistence of a stage or phase through which all children pass (Mitchell 1988; Wachtel 2003).

Based on findings from complexity theory, Wolff (1996) has raised similar objections about psychoanalytically informed developmental research. Citing research that indicates that nonlinear growth and change abound during the course of development, Wolff suggests that discontinuities are often overlooked because of forced efforts to find continuity between early and later behavioral patterns, structures, and functions through the overemphasis on surface similarities and thematic affinities. As an alternative, Wolff argues that complexity theory demonstrates that interacting, functional, and competent components of a system can organize themselves spontaneously into emergent and task-specific ensembles or collectives, which cannot be reduced or traced back to preceding states. Moreover, he writes that "competent elements are not committed irrevocably to any specific ensemble at the macroscopic level; rather, they are 'soft-assembled' and can enter freely into new coalitions to induce qualitatively different patterns of coordination as the system's initial conditions change" (385). These observations led Wolff to conclude that infant observation was irrelevant to the psychoanalytic effort to understand adult psychopathology.

In my judgment, the effort to find continuity between early and later states is, in part, an outgrowth of understanding the mind in terms of linear dynamics. In fact, to keep the linear dynamics intact, frontloading was both understandable and necessary. Said differently, when our thinking is based on linear dynamics, it is natural to assume that complexity must arise from equally complex initial conditions, components, and processes. It is this linear assumption that has led psychoanalysis to write complexity into the initial conditions of the mind and, in turn, reach conclusions about the mind that are often untenable, unwieldy, and superfluous.

Cellular Automata

As a way of setting the stage for offering an alternative, nonlinear model of symptoms as emergent phenomena, I turn to CAs. John von Neumann and Stanislaw Ulam were the first to introduce the concept of CAs in the 1950s (Peterson 1998). CAs are deterministic computational systems comprised of a number of identical, locally interacting components that evolve in parallel according to fixed rules (Ilachinski 2001; Wolfram 2002a). CAs demonstrate that emergent, complex behavior can arise from very simple underlying dynamics. The simplest CA is comprised of the following:

- A one-dimensional tape of equivalent squares called cells.
- Each cell can take on a finite number of discrete states. For instance, at the simplest level, a cell can assume one of two states: black or white, or in binary terms, 1 or 0.
- Each cell interacts only with cells in its designated neighborhood. The size of the neighborhood determines which of the adjacent cells are to be considered in determining the status of the cell at the next step. For

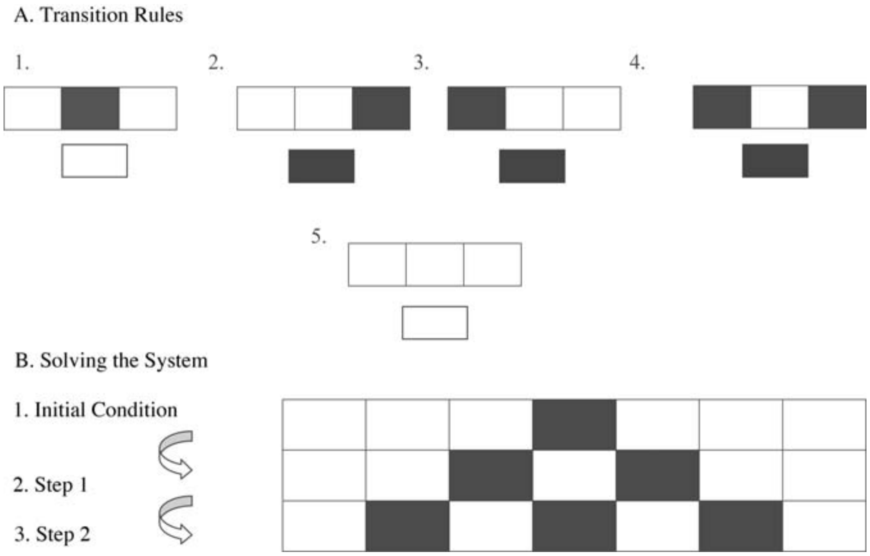


Figure 4.1

> instance, in the case of a simple, one-dimensional CA, the neighborhood is comprised of the neighbor to the left and right of the cell.

At each time step, all the cells update their status in parallel according to fixed transition rules that take into account a cell's current status (as black or white) and the status of its neighboring cells.

Figure 4.1 depicts a set transition rules (A1–5), the system's initial condition consisting of a single black cell (B1), and the changing states of the system through two iterations (B2 and B3). By applying the appropriate rule, the status of each cell at the next iteration is determined. For instance, rule A1 states that when the cell is black and its neighbors to the right and left are white, the cell turns white at the next step. As it turns out, this is the appropriate rule to apply to the black cell of the initial condition of the system as reflected in B1. As such, the cell's status at B2 is white. Taking each cell and its neighbors in turn, the process is then repeated for the all other cells in the initial condition (B1) to arrive at the entire tape shown in B2. To arrive at the status of the system after two iterations (B3), the process is repeated again, and so on for subsequent iterations. It should be noted that while the status of the system changes at each iteration, the transition rules are held constant.

While this is the basic design of a simple CA, researchers often tailor the parts to suit their specific needs. For instance, researchers can:

- Change the dimensions of the CA from one-dimension to two-dimensions (represented as a lattice or X-Y coordinate grid) or three-dimensions (represented as a cube).
- Change the number of discrete states each cell can assume. For instance, the cells can assume a range of colors along a gradient, rather than just black or white.
- Change the type of neighborhood. For instance, with two-dimensional CAs one can use a von Neumann neighborhood (the four neighbors to the north, south, east, and west), a Moore neighborhood (the eight cells surrounding the cell) or a Hexagonal neighborhood (a von Neumann neighborhood plus the neighbor in upper left and lower right corners).
- Change the complexity of the rule by adding constants. For instance, the rule might state that the value of the cell at the next step is equal to the total number of black cells in the neighborhood multiplied by a constant, with the resulting value corresponding to a particular color.
- Change the specificity of the rule. For instance, the rule might state that the value of the cell at the next step is determined by the total number of black cells in the neighborhood (totalistic rules), or state that only specific cells in the neighborhood are to be considered when adding up the total number of black cells (nontotalistic rules).
- Finally, create agents with their own rules, which move along the lattice (which is following its rules) and interact with other agents and the lattice in complicated ways.

From this brief review, one can see that these models offer researchers a range of options. The critical message about CAs is that they generate collective, coordinated patterns and structures with a degree of complexity that is not represented in any one part of the system and could not be predicted from knowledge of the underlying rules and/or the initial conditions of the system. In short, CAs offer a basic, generic model for understanding the dynamics of emergence. In this research, the way these emergent structures are observed is by examining the CA's pattern of activity over time. In this way, the complexity of the pattern serves as an indicator of the complexity of the system's behavior.

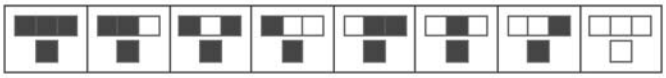
Wolfram's One-Dimensional Cellular Automata[1]

Stephen Wolfram (2002a) is one of the central figures in the research on CAs. Among the reasons his work is important is that he has studied in depth the simplest CAs—one-dimensional CAs whose rules are based on the status of the cell and the status of its two neighboring cells (left and right), and each cell has only two discrete states, either black or white. From this sized neighborhood (a cell and its two neighbors) and with cells only able to assume one of two discrete states, only 256 sets of rules are possible.[2] In his research, Wolfram studied the patterns produced from all 256 sets of rules and found that the patterns broke into four relatively distinct types or classes. This finding led him to devise a classification scheme that could be used to differentiate systems (including many natural and biological systems) based on the complexity of their pattern of behavior.

Importantly, Wolfram has studied more complicated CAs, but among his more interesting conclusions has been that the simplest CAs produce the entire spectrum of conceivable patterns, ranging from repetitive and fractal patterns to complex and random patterns. This means that complex rules and complex initial conditions are not required to arrive at complex patterns of behavior.

Figure 4.2.A depicts a set of transition rules that cover all the possible combinations of a cell and its two neighbors. This set of rules serves essentially as a computational key for determining a cell's status at the next step. For instance, the left-most rule on figure 4.2.A states that when the cell is black and its two neighbors are black, the cell turns black at the next step. The initial condition of the system consists of single black cell (top line of 4.2.B). From this initial condition, figure 4.2.B depicts the pattern that

2A. Transition Rules



2B. Class I system—simple, repeating pattern of behavior

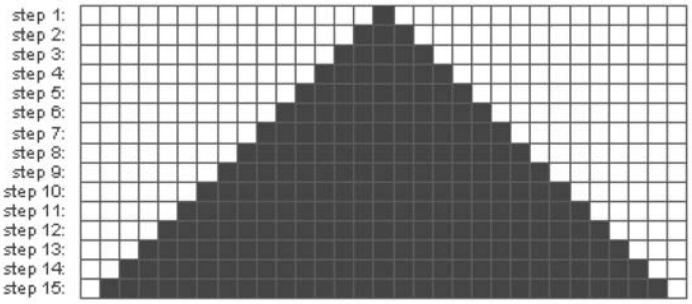


Figure 4.2
Source: Wolfram, 2002b. *A New Kind of Science, Explorer 1.0.*

emerges through fifteen applications of the rules to the changing state of the system. As noted earlier, the pattern that emerges is critically important because it serves as an indicator of the complexity of the system's behavior.

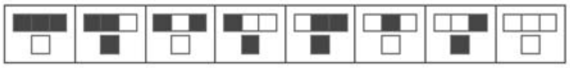
In this particular case, a simple repetitive pattern of black cells has emerged. This pattern, as it turns out, would be repeated regardless of the number of iterations. This is an example of what Wolfram calls a Class I system. Class I systems show a simple homogeneous pattern of behavior that repeats forever. In addition, these systems are insensitive to changes in the initial conditions. That is, changing the initial conditions (for example, from a single black cell to a random array of cells) does not change the overall complexity of the pattern, and the effect of any perturbation is typically stamped out over time. This means that Class I systems are extremely stable and regardless of initial conditions will generate a simple, repeating pattern. A system's sensitivity to initial conditions is also an important issue when thinking about dynamic systems in general because it is an indicator of the system's stability, responsiveness, and capacity to adapt to changing circumstances.

Although the pattern of behavior that emerges in the Class I system depicted in figure 4.2 is itself rather simple, far more complicated patterns of behavior can emerge when slight changes are made to underlying transition rules. For instance, in figure 4.3 a more complicated pattern of behavior emerges when slight changes are made to the underlying rules (figure 4.3.A). It should be noted that the initial conditions for the systems depicted in both figures 4.2 and 4.3 are precisely the same: a single black cell. Figure 4.3.B is a depiction of the pattern of behavior that emerges after 254 iterations.

Figure 4.3.B is an example of what Wolfram refers to as a Class II system. Class II systems are typically comprised of a set of repeating substructures with the whole pattern consisting of nested, scale-invariant, self-similar versions. In short, the pattern of behavior often generated by Class II systems has a fractal organization. While less so than Class I systems, Class II systems are also relatively stable and changes to the initial conditions do not change the overall complexity of the pattern.

Changing the underlying rules slightly again, figure 4.4 depicts the emergence of a pattern of behavior that is in many respects random. In fact, Wolfram (2002a) has demonstrated that the center column of this pattern produces a random string of black and white cells (or 1s and 0s in binary terms). As was the case in previous examples, the system's initial condition consisted of a single black cell. Using Wolfram's scheme, this is an example of a Class III system. Class III systems are chaotic systems, meaning that the patterns that emerge do not develop any regularity. Like all chaotic systems, Class III

3A. Transition Rules



3B. Class II system—nested, fractal pattern of behavior (254 iterations)

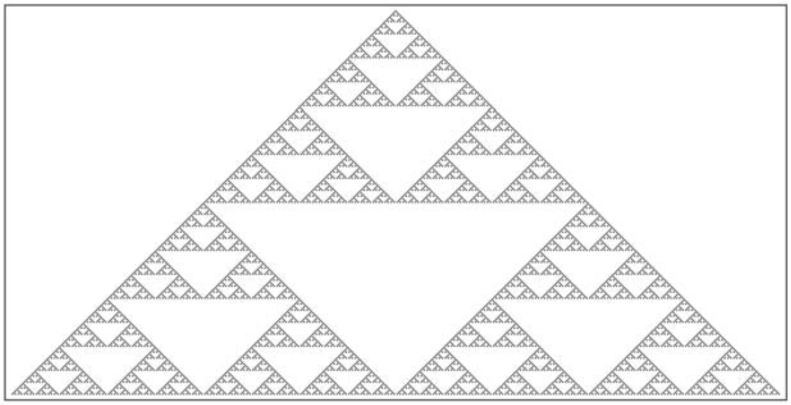


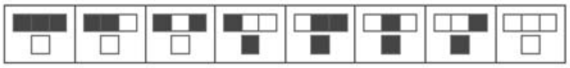
Figure 4.3
Source: Wolfram, 2002b. *A New Kind of Science, Explorer 1.0.*

systems also exhibit sensitive dependence on initial conditions, meaning that these systems are highly unstable and that any change to the initial conditions may result in a radically different pattern of behavior.

Changing the underlying rules a final time and again beginning with a single black cell, figure 4.5 depicts the emergence of a complex pattern of behavior. This is an example of what Wolfram refers to as a Class IV system. Class IV systems are complex systems because they exhibit both regularity and randomness, or aspects of Class II and Class III systems. For example, along the left edge of the pattern (figure 4.5.B), a repeating pattern of different-sized triangles is observed. Toward the middle, however, a far more irregular and apparently random pattern is observed. Class IV systems are responsive to changes in initial conditions, but exhibit greater stability than Class III, chaotic systems. In this way, Class IV systems exhibit order and stability as well as the capacity for adaptation and change.

Class IV systems are systems that Kauffman (1995) and Langton (1992) refer to as on the "edge of chaos." That is, they are neither overly stable and rigid nor fluid and chaotic. Kauffman (1995) contends that living systems evolve "toward a regime that is poised between order and chaos . . . [and that it is] near the edge of chaos—this compromise between order and surprise—

4A. Transition Rules



4B. Class III systems—apparently random pattern of behavior (254 iterations)

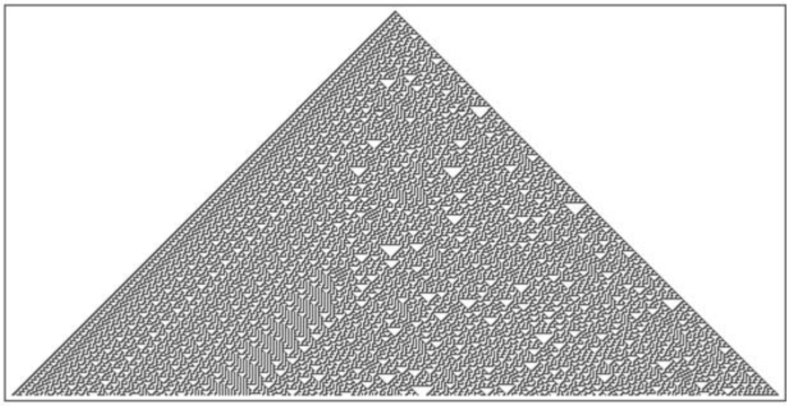


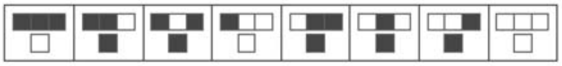
Figure 4.4
Source: Wolfram, 2002b. *A New Kind of Science, Explorer 1.0.*

(that systems) appear best able to coordinate complex activities and best able to evolve as well" (26). Applying these insights to psychoanalytic theory and psychopathology, Palombo (1999; see also chapter 1) spotlights Class IV systems, suggesting that ". . . the ordered realm near the edge of chaos is the optimal condition for human mental activity" (1999, 207). By contrast, Palombo suggests, "pathological mental states can be characterized by their location in the frozen and chaotic regimes far from the optimal level of activity" (1999, 207).

It should be stressed that the patterns produced by Class III and IV systems are emergent because the rules underlying the systems provide no clues as to the complexity of behavior that might emerge. Said differently, Class III and IV systems are "computationally irreducible," meaning that the only way to discover their long-term pattern of behavior is to run the system through several iterations.

Although there is much more to address about Wolfram's important work, in this chapter I will emphasize two points. First, Wolfram's work demonstrates that from simple initial conditions (just one black cell), systems governed by transition rules can generate a wide range of patterns of behavior, from the simplest to most complex. If we generalize from the CAs patterns of

5A. Transition Rules



5B. Class IV system—pattern of behavior containing order and apparent randomness (254 iterations)

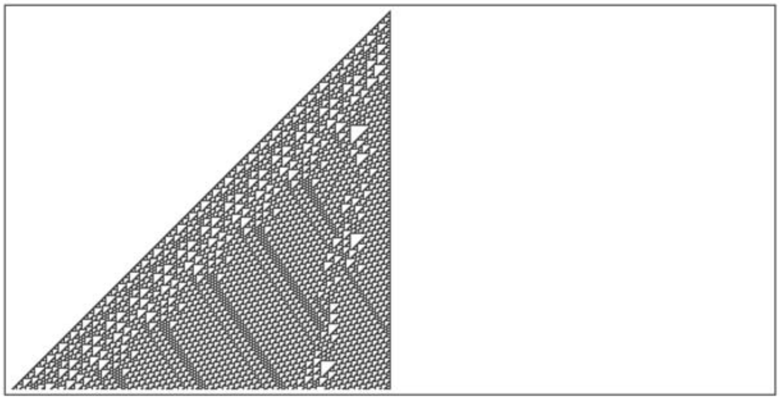


Figure 4.5
Source: Wolfram, 2002b. *A New Kind of Science, Explorer 1.0.*

behavior, we can conclude that we do not need to start with complex initial conditions and complex rules to arrive at complex patterns of behavior. Stated concisely, complexity arises from simplicity. And second, slight changes to the underlying rules can lead to qualitatively different patterns of behavior.

Conway's "Game of Life"

Martin Gardner (1970) first introduced John Conway's "Game of Life" in a column for *Scientific American*. In developing the game, Conway, an Oxford mathematician now at Princeton, wanted to create a computational system that, once started, propelled itself and whose behavior was deterministic, but nevertheless unpredictable (Peterson 1998). In the end, Conway's efforts produced one of the most vivid demonstrations of how a set of simple rules can lead to complex, emergent phenomena.[3]

The Game of Life is played on a two-dimensional grid or lattice. Each cell on the lattice can assume one of two states: alive (black) or dead (white). At each time step, individual cells determine their status at the next iteration and then all the cells update their status in unison. A cell's status at the next step (as alive or dead) is based on simple transition rules pertaining to its current status and the status of its eight surrounding neighbors (a Moore neighborhood). The rules of Life are as follows:

- For a living (black) cell to survive and go to the next round, any two or three of its neighbors have to be alive. Restating the rule in terms of the "life" metaphor, if less than two of a living cell's neighbors are alive, the cell dies (or goes white), as if from loneliness. If more than three of its neighbors are alive, the cell also dies, as if from overcrowding.
- To make this microworld complete, a cell is born (or turns from white to black) if three of its neighbors are alive.

Conway's simple system has proven to be remarkably robust and generative, producing emergent structures that are irreducible and unpredictable from knowledge of the rules and/or initial conditions. In fact, from virtually any set of initial conditions, one is highly likely to observe collective and coordinated emergent structures, patterns, or organizations. Moreover, many of the emergent structures appear so regularly in Life that Life enthusiasts have come to name them. For instance, one particularly common emergent has been dubbed a "glider" because of the way the five-cell emergent structure moves diagonally across the lattice. Figure 4.6 depicts the five phases of a glider's evolution, through which the glider cycles repeatedly as it moves across the lattice. Linking this to the definition of emergence, the glider is emergent because there is nothing written into the underlying rules or initial conditions that would lead us to anticipate its arrival on the scene.

Far more complicated emergent structures also regularly appear in Life. As a modest example, figure 4.7 provides five snapshots of a coordinated ensemble in which a glider moves back and forth between two pentadecatholons (a structure that repeatedly cycles through fifteen states). With figure 4.7.A serving as the initial condition, the glider slides down toward the lower pentadecatholon (figure 4.7.B), and by the thirtieth iteration (figure 4.7.C) has been turned around by the lower pentadecatholon and starts returning toward the upper pentadecatholon (figure 4.7.D). By the sixtieth iteration, it has returned to the initial conditions (figure 4.7.E). Providing the coordinated ensemble is not disturbed by other structures on the lattice, it will continue this period of sixty cycles without end.

Wolfram (2002a) has determined that the Game of Life is a Class IV or complex system. Like other Class IV systems, the Game of Life demonstrates the capacity for order and regularity in the form of emergent structures, but also an acute sensitivity to initial conditions. For instance, if just one renegade

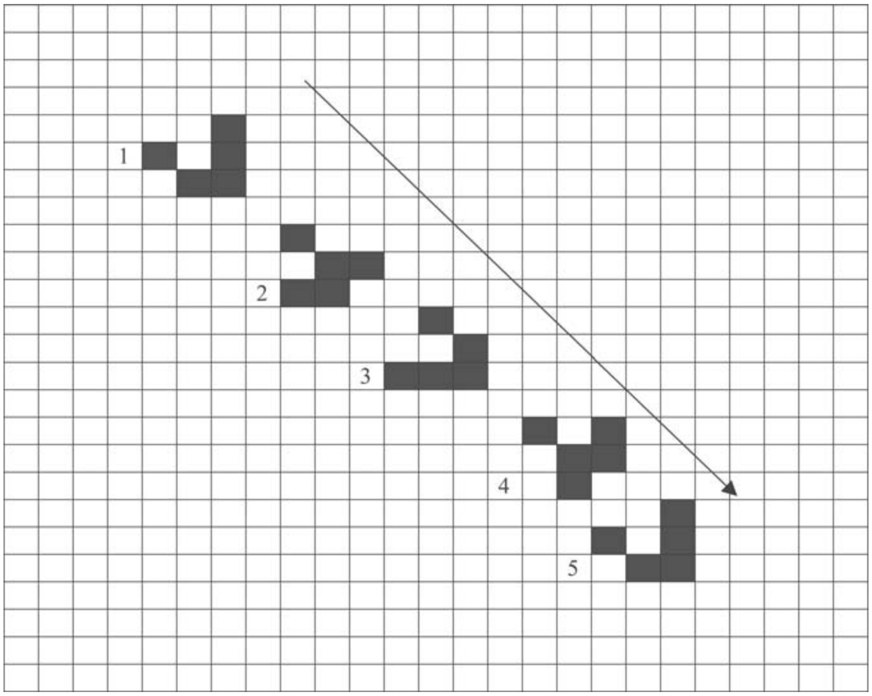
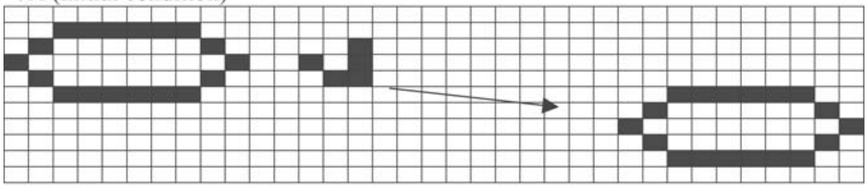


Figure 4.6. Phases of a "glider"

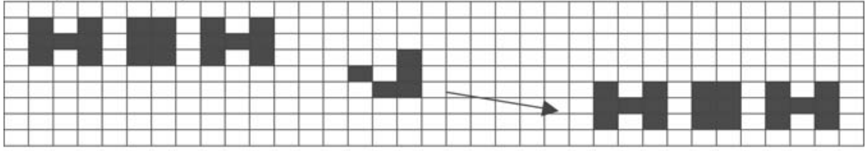
live (black) cell was inserted into one of the pentadecatholons in figure 4.7, the entire organization would quickly disassemble, ultimately leading to the development of new emergents.

Like the glider, the emergent structure depicted in figure 4.7 could be properly referred to as a first-order emergent. That is, in both cases each cell has unit status and the first-order emergents arise from the interaction of cells. But suppose that first-order emergents could, at some critical point, achieve unit status and maintain their structural integrity, and further, that accompanying their development was the emergence of a new set of rules that were as simple, but were irreducible to the first set of rules. This could lead to a situation wherein first-order emergents could themselves interact to produce second-order emergents. Although the fundamental dynamics would remain the same at all levels—simple transition rules and local interaction—one could begin to imagine a more hierarchically arranged and layered dynamic system. With just such a system, complexity theorists could develop a model that may begin to approach the complexity of the mind.

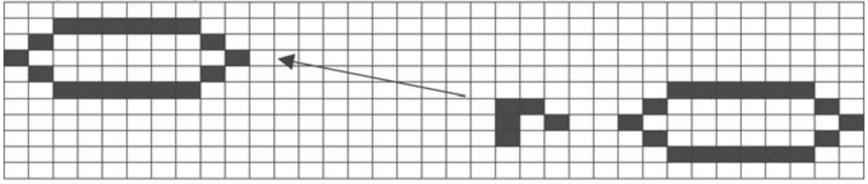
7A (initial condition)



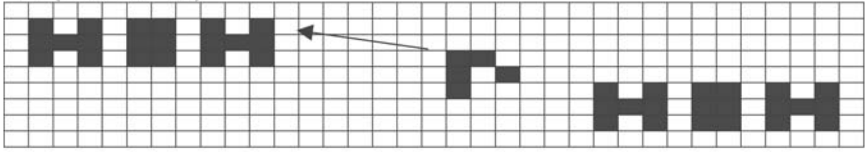
7B (iteration = 8)



7C (iteration = 30)



7D (iteration = 38)



7E (iteration = 60)

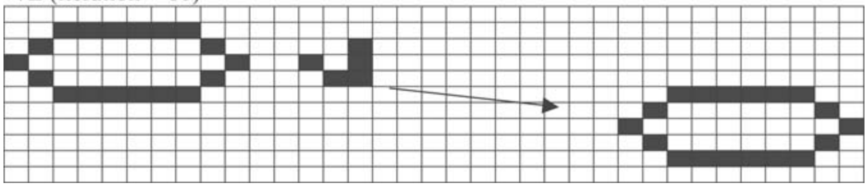


Figure 4.7. "Glider" moving between two pentadecatholons

Agent-Based Modeling

Agent-based modeling is a further elaboration of the CAs reviewed in this chapter so far. In these models, multiple and often heterogeneous "agents" move across the lattice (serving as a "dynamic landscape"), interacting and affecting each other as well as the landscape on which they roam. As is true of the other CAs, each agent's behavior and the evolving landscape are determined strictly by simple rules that take into account the agent-to-agent and agent-to-landscape interactions. Importantly, researchers have demonstrated that these simulated social networks generate emergent phenomena that are often strikingly similar to phenomena observed in real-world social and biological systems.

Epstein and Axtell (1996) are among the leading figures in agent-based modeling. They suggest that among the advantages of agent-based modeling is that the models incorporate elements that are more characteristic of actual human and social systems. For instance, the agents in these models act according to local information, thereby incorporating the "bounded rationality" or imperfect information people have in real-world decision-making. Agent-based modeling is also more in keeping with real systems because the global and collective structures emerge from the "bottom-up," rather than determined by top-down rules or an overarching "invisible hand" guiding the system's evolution.

In Epstein and Axtell's model, agents live, roam, and die on "Sugarscape," a two-dimensional landscape wherein each cell of the landscape holds a different concentration of sugar. The agent has one task: to search out, consume, and store sugar. If an agent finds itself depleted of sugar, it dies. In their pursuit of sugar, agents are endowed with three simple characteristics: locomotion, vision, and metabolism. Taking them in turn, agents are allowed to move in one of four directions (north, south, east, and west) in their pursuit of sugar; agents are able to look various distances across Sugarscape to assist them in determining where to move next; and agents metabolize their sugar stores at various rates as they move across Sugarscape. While Epstein and Axtell typically set locomotion as a fixed variable, in their simulations they usually begin runs by randomly distributing agents across Sugarscape and endowing each agent with varying degrees of vision and metabolism. This allows for a more faithful modeling of the heterogeneity of agents in real-world systems.

Based on this simple model, Epstein and Axtell have observed numerous emergent phenomena that approximate real-world phenomena. For instance, when the population of agents was examined as a whole after a sufficient number of iterations, they found that most of the wealth (defined by each agent's personal sugar store) was held by a small number of agents, paralleling the skewed distribution of wealth found in the United States. A second interesting finding was that under certain circumstances, agents are able to move collectively in ways unavailable to any agent on its own. That is, a direction unavailable to any one agent in isolation (in this instance, moving in a diagonal direction) becomes available to each of the agents when acting in concert with other agents.

This review only scratches the surface of Epstein and Axtell's important work. Indeed, by adding and subtracting simple variables to this basic design they have been able to develop models that faithfully replicate the dynamics of trade, warfare, and disease processes, just to name a few. In each case, they have observed emergent phenomena that in many respects parallel real-world phenomena.

Resnick (1994) has also contributed a great deal to the literature on agent-based modeling. In his work, Resnick has modeled systems ranging from the life cycle of slime mold to the propagation of forest fires. In each case, emergent phenomena derived from deterministic models based on simple rules and local interactions are often observed. For instance, in modeling traffic jams, Resnick replicated the way a collective jam of cars moves in the opposite direction to the forward flow of individual cars. As was the case in Sugarscape, the backward direction of the collective jam is emergent because it moves in ways that are not written into the underlying rules and is qualitatively different from any one car's movement in isolation.

Symptoms as Emergent Phenomena

In what ways are symptoms qualitatively different and irreducible to an individual's preexisting and ongoing state of mind, including conscious and unconscious mental contents? Symptoms are emergent in at least two respects. First, symptoms represent a rupture or qualitative shift in the individual's experience of volitional self-direction or agency. This assertion is based on the observation that people seeking psychotherapy commonly report that they feel compelled to do things they don't want to do; feel things they don't want to feel; think things they don't want to think; say things they don't really mean; are held responsible for actions they didn't really mean to commit; or are "unable" to end relationships they insist are not good for them. In short, to a greater or lesser degree people seeking therapy regularly report feeling impinged upon or controlled by influences (or "impulses") that they experience as foreign or less than fully their own. Indeed, it is often the distress generated by the felt loss of volitional self-direction that first brings people to therapy. In its most extreme form, this quality of symptoms is evident in auditory and visual hallucinations as well as other psychotic experiences (e.g., thought insertion and referential thinking), wherein the individual does not experience himself as the source of the voice, perception, or thought.

The second way symptoms are emergent is that they arise from a psychological context that does not at first glance contain the necessary ingredients to explain their arrival. That is, symptoms often seem inscrutable, peculiar, and nonsensical. I think there would be little disagreement among theorists from even widely divergent orientations that these are two generic characteristics of symptoms and set symptoms apart from other forms of human experience and activity. Furthermore, it is my view that they offer the most compelling evidence that symptoms are indeed emergent.

As reviewed earlier, psychoanalysis has traditionally explained these two characteristics of symptoms with the unconscious, in which anachronistic mental contents are held and can, under the right circumstances, suddenly resurface in the form of compromise formations. In so doing, however, psychoanalysis developed a nonemergence, linear model of symptoms. That is, the symptom was thought to be a linear combination or mixing of mental contents already present in the preceding state of mind, albeit tucked away in the unconscious.

But if we take the models from complexity theory seriously and conceptualize symptoms as truly emergent, we would need to shift our attention away from preserved mental content and zero in on the transition rules that characterize the way an individual organizes subjective experience, including mental contents. This brings me to the mind's attitudes. An attitude describes an individual's unconscious and fairly continuous way of approaching, experiencing, and organizing subjective experience. As such, attitudes can be cast as a set of transition rules that govern the way the flow of subjective experience is organized into subjective states. In this way, unconscious attitudes are akin to the embedded rules of a CA, inasmuch as both govern the complexity of the system's pattern of behavior and are the sources of emergent phenomena.

In cases of psychopathology, the individual's attitudes or ways of organizing subjectivity are based on restrictive transition rules that aim to dispel or forestall anxiety by, one, diminishing the individual's experience of agency, and two, defensively estranging the individual from aspects of his own ongoing subjective experience (tendencies, thoughts, feelings, sensations, and reactions) because those aspects are antithetical and destabilizing to his attitude, and as a consequence, stimulate anxiety. Careful consideration of the self-estranging properties of restrictive organizing attitudes sheds light on the underlying psychodynamics of pathological conditions. Understanding the dynamics is based on appreciating that restrictive attitudes are intrinsically conflict generating. That is, the restrictive nature of an individual's attitudes often puts him at odds or in conflict with himself (or aspects of his own subjective experience). The anxiety stimulated by even the faint awareness of such conflicts leads the individual, in turn, to reflexively tighten, intensify, or increase the restrictiveness of his attitudes. Embodying an even more restrictive set of attitudes, in turn, leads to broader areas of conflict and an increased potential for anxiety. In essence, restrictive organizing attitudes generate self-sustaining and, at times, intensifying positive feedback loops. From this conceptualization of the dynamics, therefore, both conflict and symptoms are seen as emergent properties of underlying restrictive attitudes.

Interestingly, Goldstein (see chapter 5) suggests that feedback loops such as the ones I am describing can be conceived of as functioning as "kernels of redundancy" and become the "seeds" of psychic organization or structure. I find this observation particularly important because when we speak of the mind's organization or structure, we are often referring to the individual's character or personality. Consequently, from this line of reasoning, the individual's character—the organization of his mind—is founded on the restrictive dynamics of unconscious organizing attitudes.

David Shapiro's (1965, 1981, 2000) work on character provides a precedent for conceptualizing symptoms as emerging from restrictive, unconscious attitudes. Among his conclusions, Shapiro (2000) has argued that slight variations in the nature and quality of organizing attitudes can lead to a wide variety of symptoms. For instance, Shapiro sees the obsessive's compulsive rituals, the paranoid's suspiciousness, and the hypomanic's driven spontaneity as emerging from a set of "rule-based attitudes," which differ in their degree of rigidity but are based on the individual organizing subjective experience in relation to ambivalently held rules or standards pertaining to whom he should be, what he should do and what he should feel.[4] In similar fashion, Shapiro contends that the psychopath's recklessness and absence of empathy, as well as, the hysteric's volatile emotionality and impetuousness emerge from a set of "passive-reactive attitudes," which differ in their degree of immediacy of reaction but are based on organizing subjective experience around what is immediately striking or available to the relative exclusion of deliberation, second thoughts, and reflection. In each of these instances, Shapiro is detailing the ways in which a difference in degree can become a difference in kind.

To more fully describe how a specific symptom can emerge from restrictive organizing attitudes, let's turn to compulsive hand washing as a test case. This symptom emerges in people who are relentlessly conscientious (Shapiro 2000). This means that their conscientiousness derives from a felt requirement *to be* conscientious, rather than solely from a set of articulated moral principles or convictions. Moreover, their conscientiousness is often accompanied by a fairly continuous and nonspecific sense that something has been left undone, or if done, has not been done enough or well enough. This unconscious organizing attitude, experienced subjectively as an ongoing tension, often drives such people to do more or to do extra, even more than they themselves think is necessary with regard to the specific activity, just to be sure.

A frame of mind organized around rules, standards, and "shoulds" is particularly well suited for the emergence of compulsive rituals of all kinds. But with regard to compulsive hand washing specifically, it helps explain why such an individual could come to think that, after washing his hands, they were not clean enough, or perhaps, had become sullied by the faucet when he turned the water off. Such a thought may well lead him to wash his hands a second time. He may then feel compelled to repeat this several more times for various other reasons, each time becoming more specific about how the activity should be performed. In order to leave the washroom and return to other activities, at some point the individual will generate a new rule that dictates the manner and frequency with which he should wash his hands. It is at this point we have the emergence of an enclosed symptomatic sequence. I say emergent because understanding the specific features of the symptom—hands, germs, contamination, washing, the frequency, etc., as well as the individual's childhood experiences with such things—is not critical to understanding the source of the symptom. Rather, the symptom emerges anew based on the individual's restrictive way of organizing experience around rules, or a sense that he has never done enough and that things should be done in particular ways. This is precisely where an emergent conception of symptoms departs from a linear conception, because the latter sees the content of the symptom as representing an encrypted linear combination of preexisting mental contents.

Earlier, I mentioned that another emergent aspect of symptomatic behavior is the accompanying, qualitative diminution of the individual's experience of agency. But let me flesh this point out further. Staying with compulsive hand washing, we can see that with the emergence of the symptomatic sequence, more of the individual's actions have become subsumed under a rule. This has the effect of further diminishing the individual's experience of agency, already attenuated by his overarching restrictive attitudes. After all, prior to the closure of the sequence, the individual felt at least some sense of agency prior to executing each step of the sequence. With the emergence of the symptomatic sequence, however, once set in motion, the sequence unfolds according to the rule. That is, more of the individual's actions are *subjectively experienced* as automatic and directed by a rule, rather than by him.

It is worth extending this discussion a bit further to demonstrate how the restrictive organizing attitudes underlying some emergent compulsive rituals—a relentless conscientiousness accompanied by a continuous and nonspecific sense of never having done enough—might shape the individual's way-of-being in psychotherapy. In the psychotherapy of one such patient, this took the form of his frequent attempts to bully and coerce himself into taking some particular action. It is important to note that the particular action changed regularly, but the urgent, persistent nagging remained the same. He often seemed to be severely scolding himself—scoldings that were regularly accompanied by insulting himself mercilessly for his inaction. If the scolding and insults were insufficient to move him to action, he would then generate various disaster scenarios that could conceivably result from his inaction. Importantly, he readily acknowledged when asked that the likelihood of such disasters befalling him was remote. This indicates that his aim in generating a list of conceivable disasters was not to realistically assess the risks of inaction, but to incite himself to action. On many occasions, he would also try to provoke a similar level of urgency and panic in his therapist, hoping to recruit the therapist in his efforts to get himself moving. When the therapist did not respond in kind, he would then scold the therapist for not doing enough to help him take his inaction more seriously and that it was high time that the therapist "take the gloves off." Of course, his nagging and scolding were intended primarily for his own ears. Indeed, the worked-up, exaggerated quality of his scolding was intended to counteract his own lack of interest in taking the action—an action he simultaneously told himself he should take. That is, his lack of interest in taking the particular action was in conflict with his recognition that he *could* take action, and ran afoul of the persistent pressure he placed on himself to do more, or at least, do everything he could. In keeping with this formulation, it is interesting to note that he would often experience a sense of relief at the conclusion of a session, particularly when he spent the majority of the time staying after himself. This was true whether or not he was any closer to taking the action. His relief seemed based on his sense that at least he had done all he could in that day's session.

Again, I provide this brief vignette to demonstrate that restrictive organizing attitudes are not just the sources of emergent symptoms, but can be seen in the way the individual organizes his subjective experience more generally and are present, to one degree or another, in a fairly continuous way.

Attitudes as Procedural Memories

Raising questions about the role of historical mental content in understanding psychopathology requires that I be very clear about what I am proposing. I am not proposing that life events, even early life events, are unimportant in determining the nature of adult psychopathology. Rather, I am proposing that the lasting effect of any life event, as it pertains to psychopathology, is determined by its impact on the nature and quality of the unconscious attitudes that organize subjective experience, rather than that impact taking the form of a pathogenic, unconscious memory of the event. One important implication of this point of view is that what is remembered, how it is remembered, and why it is remembered is not thought to be determined primarily by the characteristics of the event and its corresponding memory, but by the current attitudes that shape the way the past is remembered and determine the significance of particular kinds of memories (Piers 1998). In this way, I am suggesting that what is remembered in a psychotherapy hour has more to do with the restrictive organizing tendencies the individual brings to bear on remembering his past in the here-and-now, rather than the event's emotional significance to him when it occurred in the past.

In response to this conceptualization of attitudes, one could reasonably agree on the central importance of unconscious organizing attitudes and, at the same time, causally link the development of attitudes to specific life events and, in so doing, again stress the therapeutic importance of working through the memories of such events. Such a line of thought would, in essence, be a way of keeping both the baby and the bathwater. While this is conceivable, such a view is reductionistic because it vastly underestimates the impact of subsequent and ongoing life events in developing a causal account for current human activity. As we have seen with nonlinear systems—of which I think the mind is one—it is impossible to isolate, predict, or reconstruct what effect any particular perturbation might have on the evolution of a system. Moreover, emergence in psychic life indicates that what is evident now is often not reducible to what came before. And finally, reducing current activity to a repetition of past events overlooks the self-perpetuating, conflict-generating, and, at times, intensifying dynamics of restrictive organizing attitudes, dynamics that can account for the emergence of symptoms and function autonomously from the myriad and varied past experiences (traumatic and otherwise) that had a hand in setting them in motion.

It is my view that a theory of psychopathology founded on unconscious organizing attitudes offers a more explanatory and parsimonious account of psychopathology than one founded on unconscious memories. I say this because the development of a restrictive attitude toward experience affects the very way ongoing subjective experience is organized into subjective states. By contrast, the effect of unconscious memories of past events would be limited to subsequent events that bear some associative, thematic, or emotional affinity, thereby limiting their explanatory power. Unconscious memories may appear to do a fair job in accounting for a single symptom (or even set of symptoms), but fall far short in accounting for the overarching organizing dynamics responsible for the coherence and continuity of form we see in adult personality, out of which a particular symptom is just one emergent expression.

Although my discussion thus far has focused on unconscious memories, a similar case can be made in relation to models that emphasize unconscious relational scripts or object relations. While models founded on memories, object relations, and organizing attitudes all have ways of accounting for symptoms and the restrictiveness of an individual's functioning, a model of psychopathology based on restrictive organizing attitudes can account for a wider range of the individual's functioning and the distinctive "self-sameness" of his functioning (Piers 2000).

This conceptualization of unconscious attitudes can be situated within current theories of memory. Among contemporary memory theorists, there is general agreement that memory can be broken down into two distinct types: declarative memory and nondeclarative or procedural memory (Squire and Schacter 2002). Declarative memories are memories for specific events (e.g., a birthday, an anniversary, or the death of a loved one), while procedural memories are memories for how something is performed (e.g., solving a math problem, playing the piano, or shooting a basketball). Recently, procedural memory has figured prominently in the work of several theorists in their understanding of psychotherapeutic insight and change (Rosenblatt 2004), personality (Grigsby and Stevens 2000; Grigsby and Osuch, see chapter 3), and transference (Westen and Gabbard 2002). For my part, I suggest that psychopathology arises from unconscious procedural memories in the form of restrictive organizing attitudes, procedures, or rules for organizing subjective experience, rather than from unconscious declarative memories in the form of traumatic childhood events, fantasies, or complex mixtures of the two. As such, treating psychopathology requires therapeutic attention to the restrictiveness of unconscious procedural memory, rather than in excavating early, unconscious declarative memory.

Conclusion

Research on CAs indicates that emergent phenomena—ranging from simple, repeating patterns of behavior to random and complex patterns of behavior—can arise in recursive systems whose evolution is based on rather simple transition rules. In that way, CAs provide a basic, generic model for understanding emergence and demonstrate that complex rules and complex initial conditions are not required to arrive at complex patterns of behavior. This research has led me to reconceptualize the mind's underlying structure, properties, and dynamics and formulate symptoms as emergent phenomena. In my formulation, I link the emergence of symptoms to unconscious restrictive attitudes—attitudes that determine the way an individual organizes the flow of subjective experience into subjective states. In so doing, I draw an analogy between restrictive organizing attitudes and the transition rules of CAs, both of which govern the complexity (or lack thereof) of the system's pattern of behavior and are the sources of emergent phenomena.

Regardless of the fate of my own particular take on this research, I venture to predict that CAs—as well as many other areas of complexity theory—will serve to stimulate new and potentially fruitful ways of thinking about the mind and its pathologies.

Notes

1. I am grateful to Jason Cawley of Wolfram Research for his clarifying comments to earlier drafts of this section.

2. The initial conditions include three cells that are either black or white. This totals 8 (or 2 x 2 x 2) possible combinations of initial conditions. At the next step, a cell can assume one of two states. Therefore the total number of rule sets equals 2^8 or 256.

3. There are several very user-friendly Life programs that can be downloaded for free from the Internet. One of the best I have found is Johan G. Bontes' "Life32." This program as well as a vast library of discovered patterns can be found at: psoup.math.wisc.edu/Life32.html

4. Shapiro's use of the word "rule" in rule-based attitudes is descriptive and far more specific than my description of unconscious attitudes in general as "transition rules," or rules that govern the way subjective experience is organized. A potential confusion arises because the rules that govern the way obsessive, paranoid, and hypomanic individuals organize subjective experience (their attitudes) are characterized by uncompromising "shoulds," standards, and rules.

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