The Fall of the Shah of Iran: A Chaotic Approach

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One of the intelligence community's highest priorities is to provide warning against surprise. There is a substantial body of literature on intelligence failures, beginning with Pearl Harbor. The common themes in these writings are the intelligence community's inability to integrate data and reach a consensus on their meaning and its inability to convey that warning to appropriate policymakers in such a way that the threat to U.S. interests is clearly defined and in sufficient time to allow action to be taken.

Furthermore, these examples include occasions where the analytic methodology led to a distorted comprehension of the facts or prevented analysts from reaching a clear understanding of the situation.

The science of chaos is a recently evolved study of nonlinear dynamical systems that offers some means to avoid these traps of analysis and decision making. In the past few years the study of chaos has moved from purely theoretical mathematical constructions to preliminary approaches to social, economic, and psychological constructs. The science of chaos emphasizes a study of the process of systems in time and not an analysis of static factors, which is a potential shortcoming of the Department of Defense Indications and Warning assessment matrix. Chaos requires an understanding of the relative degree of integration of subelements of a system, the effect of initial conditions, and the problem of prediction in nonlinear dynamic systems.

This paper analyzes the fall of the Shah of Iran in 1978 and 1979 using principles brought forward in recent writings on chaos and other systems that exhibit so-called "self-organizing criticality." It compares this approach with published accounts of intelligence analysis and reporting during 1975–79. Using a small number of specific features of these disciplines, the paper concludes that chaos is a reflection of how human systems actually function and that using the principles of chaos leads to a more insightful understanding of the forces at work, their interactions, and potential outcomes.

INTRODUCTION

On 16 January 1979 the Shah of Iran left his country for the last time. His government was in collapse and the country in turmoil. He was battling cancer, and his ally for many years, the United States, had all but abandoned him. Although this was not the first crisis the Shah had endured, it proved to be one more battle than he could win. For a number of reasons, the U.S. intelligence community in 1977 and 1978 failed to give adequate warning to policy-level officials that the Shah's government was in a precarious state. The fundamental approach to analysis of events in Iran used the rational actor model, viewing the Shah and Iran as essentially synonymous. This viewpoint could only result in a sadly oversimplified understanding of Iran's society. Thus the prevailing opinion and, in fact, the only opinion on the state of the country was the Shah's, and his opinion was severely biased. The U.S. had no source of credible information to counterbalance this narrow perception.

I will propose in this paper that an alternative analytic approach might have forced the intelligence community to look at the information that was available and to view that information in an entirely different way. The significant features of chaos and one of its subsets, self-organizing criticality,[1] if applied to the events and forces that preceded the fall of the Shah of Iran, would have led analysts in the mid- to late 1970s to examine indicators that might have provided a different understanding of the situation in Iran and given some warning of the weaknesses and latent instability of the government, permitting some anticipation of the possible outcomes that could threaten U.S. interests. I will look briefly at the background to the U.S. relationship with Iran, present some basic features of chaotic systems, consider if those features could be found in Iran in the 1970s, and then compare those results with the limited analysis that the rational actor approach provided.

The science of chaos has attracted increasing attention in applications to analysis of human affairs. Although founded in the studies of nonlinear phenomena in physics and mathematics, as of late much greater effort has gone into applying the principles of chaos to large-scale economic and social systems. Even the earliest researchers had been able to find features of chaos in the growth and fall of animal populations and the spread of diseases such as measles. They exhibited patterns of change that matched the non-repeating and yet bounded cycles of chaos.

Chaos and criticality provide a means to avoid some of the common traps of analysis and decision making that plague the intelligence community. Chaos insists on looking at entire systems rather than trying to break down phenomena into component parts. As such, chaos emphasizes the process of a system and the changes that occur in that process over time. The broader view helps prevent tunnel vision, encouraging consideration of all factors, large or small. I believe, intuitively, that in modeling on the basis of cycles that do not precisely repeat, but remain bounded in a mathematically definable fashion, we come closer to a description of how human systems actually work. Another reason for believing chaos to be a useful framework for analyzing social, political, and cultural change is the

concept of self-similarity, that some systems are controlled by common rules at differing levels of scale. Another attractive feature of chaos is universality, the principle that different nonlinear systems may have inherently identical structures, identical because chaos is universal; it describes fundamental principles by which our universe functions. We can therefore expect to find reflections of chaos in a wide range of seemingly disparate events. The study of criticality, complexity, and self-organizing systems has a similar appeal. The idea of criticality and metastability seems to describe events and trends that we actually see in the "real world." For the intelligence community, each of these reasons offers a means of improving the methodology of analysis, as a model based on principles of chaos may yield more accurate and insightful analysis and produce more relevant and timely conclusions.

Key Judgments

Chaos would have pointed to the turbulent history of Iran as an example of a self-organizing metastable system. The basic features of chaos would have shown the weakness in cohesion, the dynamic environment occasioned by multiple independent actors, the repeated incidents of sensitivity to initial conditions and the self-similarity of conflict at different levels of the society and government. Chaotic systems are not predictable for the specific reason that human perceptions are incapable of producing sufficiently accurate measurements of the starting conditions and even the smallest difference in precision in a chaotic system will give completely different outcomes. Identifying Iran as a system verging on chaos would have allowed sufficient warning to policymakers so that adjustments in U.S. actions could have been made to better protect our interests.

BACKGROUND

Our relationship with Iran had been the cornerstone for U.S. Middle Eastern policy for over ten years. The U.S. had provided material assistance and political and moral support, and Iran had, under a carte blanche policy, purchased some of the most up-to-date U.S. weapons systems.[2] Little was said of the Shah's repressive regime. In fact, the campaign promises on human rights that President Carter made in 1976 would become a haunting counterpoint to the reality of the secret police, the SAVAK. The Carter administration was forced to balance the moral stance of the president against the realities of the Middle East situation, in which U.S. friends were few and far between in a region that was so strategically vital as a source of oil and a major route to Asia.

Under these circumstances, the failure to predict, and thus prepare for, the fall of the Shah became a major issue in the relationship between intelligence and policy. It is generally believed that the U.S. intelligence community failed to analyze correctly the situation in Iran and failed to make the government sufficiently aware of the potential outcomes. Intelligence did not grasp the strength of the opposition to the Shah, the influence of the conservative religious leadership on the country's almost feudal culture,

represented in particular by the Ayatollah Khomeni, the Shah's distance from, and antipathy towards, most of the population, the lack of cohesion in the military, and the consequences of his push to modernize and liberalize the economy. Not only did intelligence fail to report an accurate picture of the social and political forces at work in Iran, but such limitations as the complete shutdown of CIA operations (done to avoid offending the Shah) were not even recognized as a serious hindrance to a balanced and effective analysis. CIA reports of the Shah's indecisive nature were ignored, and his illness came as a complete surprise. Even as the turmoil began to grow, the feeling was that the Shah would find some way out, as he had done in the 1960s, and all would be well.

SELF-ORGANIZING CRITICALITY AND CHAOS

The theory of scientific investigation that prevailed well into the twentieth century was that of reductionism.[3] An event or process was broken down into its component parts, all future change was defined by cause and effect relationships, and predicted from observed conditions. The advent of the science of chaos in the mid-twentieth century spread like a shock wave across the landscape of physics and mathematics. One system after another was recognized to exhibit behavior that could not be predicted precisely over time, whose future was nonlinear and nondeterministic.

During the early years of investigation, researchers found that many natural systems, from the structure of the human lung to the formation of snowflakes, followed the same patterns of change, which could be derived from the same formulas,[4] as if there were a class of rules that governed their behavior.[5] This class of rules described processes, both those that occurred in nature independent of the influence of man and those that were inalterably tied to human interaction.

Features of Chaos

At this point, chaos has been reduced to a manageable set of features, whose manifestations can be seen without a detailed knowledge of the math involved. The features are

- Nonlinearity
- Aperiodicity
- Dynamism
- Sensitivity to initial conditions
- Attractors (Bounded domain)
- Universality
- Self-similarity

A branch of chaos, sometimes called weak chaos, has been applied to the dynamics of earthquakes, ecosystems, and turbulence in fluids. It was formalized as the theory of self-organizing criticality and describes systems that

> . . . evolve to a critical state in which a minor event starts a chain reaction that can affect any number of elements in the system . . . . Furthermore, composite systems never reach equilibrium but instead evolve from one metastable state to the next.[6]

Features of Self-Organized Criticality

Steven Mann suggested four factors[7] that might be among those that would shape criticality.[8]

- The initial shape of the system
- The underlying structure
- Cohesion among the actors
- Conflict energy of the individual actors

The cycling from metastability to reordering is an inherent feature of self-organized criticality.[9] It is self-sustaining, not requiring external forces to initiate or sustain change.

ANALYSIS

In the case of Iran, the four features of criticality noted by Mann would lead us to facts that were obscured by concentrating only on an analysis of the Shah as a rational actor.

The Initial Shape of the System

The Shah's plans for liberalization of the economy and expansion of democratic institutions were in direct contrast to the long history of the autocratic monarchy. Even a superficial review would suggest that the Shah would have to give up a significant degree of control if he were to realize a modern market-driven system. One of the widely respected religious leaders, the Ayatollah Khomeni, had been in exile in Iraq for fourteen years. The continued influence of the Ayatollah Khomeni after more than a decade in exile was a clear indication that any secularization of the country would face formidable opposition. Iran was a monarchy, whose economy depended primarily on the sale of oil. The wealth that had come in the wake of nationalizing the oil companies had led to an increasingly prosperous, although for the Middle East rather new, middle class. The Shah had embarked on a program of westernization and liberalization, which was causing some tension between this new middle class and the more conservative, religious elements. The Shah maintained a close relationship with the United States, which had made Iran an important part of its regional policy. (An identification that was to cause problems later on.)

The Underlying Structure

Geography plays an important role in fixing Iran's place in the Middle East. Its position between Europe and Asia and India gives it a strategic thrust. Its proximity to the Former Soviet Union (FSU) makes it important in questions of Soviet expansion and influence in the Middle East. With U.S. policy committed to support of Israel, having any

ally anywhere in the area was of paramount importance. Economically, Iran had substantial oil resources, which enabled it to maintain a program of economic expansion and liberalization. Its military forces had been built through purchases of arms from the United States, a program encouraged by the U.S. in order to strengthen its strategic position in the area. Politically, the Shah dominated the government, tolerating little or no opposition. He had held power through periodic applications of force, both real and psychological. Society was fundamentally conservative, religious, almost feudal.

Cohesion among the actors

From Mann, "Cohesion determines the rate at which reordering takes place."[10] Examples of the presence or absence of cohesion are easy to find. The upper and lower class were very much estranged, reflective of the Shah's antipathy toward the people in general. This division was exaggerated by the liberalization of the economy, the military buildup, the rise of a more secular entrepreneur class, and the harsh measures employed by the government to protect the power of the Shah. The identification of the Shah as a puppet of the U.S. grew rapidly. The cohesion between Iran and the U.S. was quite strong, but depended entirely on the Shah and actually weakened cohesion between segments of the population and the government, who perceived the U.S. as having excessive influence and faulted the higher political and military institutions for this relationship. The cohesion in the military was weak, especially between the upper and lower levels of the officer corps. Iran enjoyed a close relationship with the other Arab states of the Mideast, but the relationship was tempered somewhat by its Persian heritage. The cohesion between the religious leaders and the people, on the other hand, remained very strong. Subsequent events showed that the unity and determination of these factions were more than enough to overcome the weaker ties of the government, the middle class, the military, and the Shah.

Conflict Energy

Mann defines this as "an active force that instigates change in the status quo, thus contributing to the formation of the critical state."[11] This force is applied by specific actors, who may be governments, political or religious movements, or individuals. As with cohesion above, there were a large number of players with active roles in Iran. The Shah was trying to effect a general change in the economy and culture, using oil revenues to liberalize the economy and upgrade the military. Religious leaders were working against these tendencies. The secret police or SAVAK worked largely to ensure the continued power of the Shah, using tactics that alienated the population and at times caused concern in the U.S. The U.S. worked to bolster the Shah's regime, but through insensitivity and/or lack of feedback, often succeeded only in feeding the Shah's latent insecurities. President Carter played a significant role in supporting the Shah, and his national security advisor Zbigniew Brzezinski was a dominant force in the administration, often short-circuiting alternative analyses of the situation in Iran.[12] The U.S. intelligence community, in playing a very passive role, insured that there were no voices raised against the course of policy. The economy also became a factor. As oil prices fell, the flow of money which had

been bolstering the economy dropped rapidly. The effect would be felt first among those most likely to oppose the Shah, the relatively conservative lower class.

From the above description it is clear that features of self-organized criticality were strongly evident in Iran in the mid-1970s. A review of the chronology of Iran from the early 1940s shows the same features although more spread out in time.[34] There is a recurring history of political instability and social unrest. There were weaknesses in cohesion in the military, society, and government. The role of the secret police, the degree of influence of the U.S., and the difficult position of the expanding, westernized middle class in a fundamentally conservative Islamic culture were all evidence of conflict energy.

Chaos

Viewing the fall of the Shah in light of the most commonly mentioned features of chaos also grants some insight into the conditions and events that preceded his leaving Iran.

Non-linearity/Aperiodic Behavior: The events that led to the Shah's downfall followed no discernible pattern in terms of time. Over the entire course of the monarchy, going back to 1941, there were periods of intense political, economic, and religious activity interrupted by stretches of almost complete calm. Within a chaotic system, islands of stability are a common feature.[14] For instance, the well-known "red spot" on Jupiter is suspected to be a temporarily stable vortex, on cosmological scales, that is, in the chaotic turbulence of Jupiter's atmosphere.[15] Threats to the stability of Iran continued to appear, engage the attention of the governments of both Iran and the U.S., and then fall into obscurity. The conflict with Mohammed Mossadegh in the 1950s over the Iranian Oil Company, the short incumbency of Dr. Ali Amini as prime minister, and the confrontations with Khomeni in the early 1960s are all examples of the aperiodic instabilities that reflected the underlying chaotic system. From the 1940s into the 1970s, these regular cycles of quiet lasted as long as five or six years, but as the level of intensity grew from 1976 to 1978, the intervals became much shorter. For instance, the celebrations for the dead at forty-day intervals created a cycle of demonstrations and reprisals by government authorities, dubbed "doing the 40-40" by Khomeni supporters.[16]

A Dynamic System: A dynamic process requires multiple actors in order to sustain activity. Systems with only one or two players or active forces tend to settle into stable or static states.[17] The multiple interactions that are required for a chaotic system were provided by a number of groups: the military, the middle class, the religious lower class, the Islamic clergy, the Shah himself, Carter, Ambassador to Iran William Sullivan, Brzezinski, and Congress.

Sensitivity to Initial Conditions: This is one of the most striking hallmarks of chaotic systems. The progress of a chaotic system through time is entirely dependent on the initial conditions. If one factor is changed in even the smallest way, the system gradually exaggerates that change, until the course becomes completely dissimilar. There can be no damping force in a chaotic system that works to negate or minimize the effect of minor changes. Each new event becomes a new "starting point," from which the system will evolve in a completely different way than it would had the event not occurred. Of the

many factors which could be presented as important in Iran, I will focus on three: the conflict in Congress over the sale of the AWACS airplanes, the demonstrations in Qom, and the use of audio tapes by the Ayatollah's followers. Each of these three incidents clearly had an effect that increased in scale and impact as time went by. If the system were rigidly linear, such relatively small incidents could not have had such an exponential effect.

The exile of the Ayatollah is an example of the disproportionate effect of small perturbations in a chaotic system. Even though he had been out of the country for many years and even though Iran was able to engineer his further banishment from Iraq to Paris, by the simple use of a touch-tone phone he was able to continue control of his followers. The Ayatollah's forces also sent back to Iran audio tapes of his speeches, which had a significant impact on his followers.

When Congress debated the sale of the planes to Iran, the Shah was personally embarrassed, while opposition elements in Iran took this as a sign of wavering support for the Shah. These perceptions precipitated other actions, such as an increase in demonstrations, both inside and outside of Iran. In November of 1977, pro- and anti-Shah groups clashed in Washington. In separating the groups, tear gas was used which was blown over into the arrival ceremonies for the Shah, who was to attend a state dinner that night. In compensation the Carter administration stepped up its level of rhetoric, intensifying the perception in Iran that the Shah's government was tied too closely to the U.S. Since the original debate in Congress had little real effect, as the AWACS aircraft were sold to Iran in the end, we see the consequences of a small incident having much larger impact over time. The incident was perceived by radicals in Iran as a sign of weakening support for the Shah and became a major factor in encouraging Khomeni's supporters.

In January and February of 1978, the riots in Qom created a new set of initial conditions. In putting down the disturbances, a large number of demonstrators were killed. This started the forty-day cycle referred to above. A similar cycle was caused by the fire at the cinema in Abadan. These were considered to be major turning points in the struggle to oust the Shah. In both cases, a single event precipitated a widening circle of disturbances that ultimately changed the course of the entire system.

Determinism: Chaos is a collection of many smaller orderly behaviors, resulting in unpredictable behavior occurring within a predictable system.[18] Determinism, on the other hand, refers to circumstances that can be described completely at any given moment, from which the future is then predictable, assuming no outside force acts to change the system.

The events of 1977 and 1978 were not remarkable, taken one by one. Religious demonstrations are commonplace around the world. There are many right-wing governments which have been supported by a threatening and violent security police. Economic disjunctions, such as the strikes and the fall in world oil prices have affected many nations, some far more severely than Iran. A chaotic system cannot be studied by

isolating one event from another, because by themselves the events are deterministic and predictable. It is only the interaction with each other that results in chaotic behavior.

Universality: Mann sets it out rather simply: "Different nonlinear systems have inherently identical structures."[19] This is the concept that chaos describes fundamental features of our existence. Chaos can appear in many different guises, because it is a reflection of how things work. Thus, a plot of cotton prices at the port in New York over the last hundred years can be described by the same equations that describe changes in average income.[20] All these phenomena are a result of the same forces, forces which are a natural feature of the world around us. This concept supports the idea that chaos can be realized in major human social movements and, if so, that features of chaos can then be used to further our understanding of those systems.

Self-similarity: The Ayatollah's audio tapes created a small whirlpool of interaction. The excesses of the secret police created another. These smaller events had the same shape and form as did larger events, such as the fall in world oil prices, which had consequences on a larger scale. Iran itself was a swirl of events and interactions. The feature that each of these events has, when the factor of scale is removed, is that of self-similarity. The term scaling is often used to describe this aspect of chaotic systems.[21]

In contrast to the generally accepted picture of Iran that held sway in the Carter administration, the picture suggested by examining potential features of self-organized criticality and chaos is that of a system on the edge of stability. The perception that the Shah was essentially in control almost to the end is seen to be untenable and the complacency of the policymakers entirely unjustified. While describing conditions of chaos does not prove its existence, using that approach in comparison to the rational actor model provides a better insight into the conditions that prevailed at the time, and would have certainly been sufficient reason to reexamine the direction of U.S. policy.

CONCLUSIONS

The rational actor approach taken by the intelligence community in 1977 and 1978 limited our perceptions of the situation to those of the Shah. Given the basic confidence in the Shah and his intentions to modernize and democratize his country, there was little in the way of critical analysis applied to his version of events, to his assurances, and reassurances that conditions were well under control. As Gary Sick points out, his view of Iran was controlled by the information passed to him by his government and court, information that was heavily edited and distorted to protect the feelings of the Shah and the jobs of the officials who surrounded the Shah. Since the Shah had little understanding of the insecurity of the middle class, the lack of cohesion in the military, and no appreciation at all for the conservative religious elements, his assurances to the U.S. regarding progress in redressing social wrongs was based on his own feelings and not on objective unbiased information. The intelligence community was unable to separate Iran

from the person of the Shah and could not provide reliably evaluative and predictive information on the possible futures in Iran.

Limited by lack of current information, the U.S. intelligence and policy communities assumed the Shah

- wanted to improve conditions for his people;
- wanted to liberalize the political as well as the economic system;
- was confident and secure in his position;
- was decisive in exercising leadership;
- had the support of the population as a whole and the military.

By viewing the Shah and Iran as essentially identical, analysts failed to see the lack of cohesion among the various elements of Iranian society. By not considering sensitivity to initial conditions and the changes that even small events may have on the course of a chaotic system, the fallout of a number of events was not considered or given proper weight. By not reviewing the conflict potential among actors, analysts could not appreciate the extremity of their positions.

We failed to see

- his insecurity and fear of competing power within his government;
- his remoteness from his vast majority of Iranians in all walks of life;
- his illness;
- the strength and depth of opposition from the clergy and the lower classes;
- his lack of "common touch."

If analysts had considered the features of self-organizing criticality and chaos as indicators of conditions in Iran, they would have seen that there were significant areas of instability and conflict which the Shah did not address in his superficial and limited reforms. The chaotic model would have forced attention on the weak foundations of the Shah's government, the interaction of the various segments of Iranian society, their lack of cohesion, and the strength of the forces against liberalizing Iran socially and economically. In the case of Iran, analysis that assumes the system was either weakly chaotic, or completely so, leads one around the shortcomings of the rational actor model and suggests the potential for instability and conflict.

Nor is Iran an isolated case by any means. The breakup of the Soviet Union and Yugoslavia and the situation in Somalia are other examples where the model of chaos may be applied. The course of events in the India and Pakistan[22] conflict suggest that analysis of those situations could benefit from an approach that looks to see if they might also be chaotic systems. A number of countries in North Africa are currently or have in the past few years endured social dislocation such that one might suspect weak chaos at work, if not the real thing.

There is one more aspect of chaos that should be examined in detail. The intelligence community has been judged often on the basis of whether or not it predicted specific events

or conditions or provided warning on those events, so that policymakers could act accordingly. The examples of these failures abound, from Pearl Harbor to the Marine barracks in Lebanon to the breakup of the Soviet Union. However, the very nature of chaos is that, within the limits of the system, it is not predictable. It falls short of the ideal of unambiguous specification of future events. In particular, the feature of sensitivity to initial conditions guarantees that the longer term future is unknown. We cannot measure phenomena stringently enough to determine precise conditions, and, failing that, we cannot know the future course of the system. The smallest error between our measurements and reality will cause a rapid and complete diversion from the expected course.

There is no doubt that chaos exists in the empirical world. However, there is a growing body of research that indicates the presence of chaos in human interactions. Diana Richards has even proposed a test for the presence of chaos in social systems.[23] If it can be proven that there is a category of social interaction that is chaotic in behavior, then the intelligence community, along with the policymakers, will have to devise a different way of approaching those problems.[24] Conventional planning to establish a policy with intelligence input that depends on choosing one possible future out of several is bound to fail, because the very choice of action (sensitivity to initial conditions) could completely change the outcome.[25] Chaos gives us a concrete rationale for saying that the behavior of some systems can be predicted accurately only in the most immediate of futures. We might be able to state that India and Pakistan will not go to war in the next three months, but we cannot make any such prediction about events in these two countries a year from now. According to the theories of chaos, we simply cannot collect enough information with sufficient accuracy to insure reliable prediction. According to T.J. Cartwright, ". . . planning based on prediction is logically impossible due to the finite nature of perception, observation, and calculation in an infinite world.[26] In the presence of chaotic systems, we may need to remain prepared for the unexpected "butterfly effects."[27]

CLOSING

I believe we live in a world of chaos. Scientists have discovered evidence of chaos in the patterns of the beating heart, the functioning of the brain, and the orbits of planets circling the sun. A number of other examples have been cited in this paper. I find it reasonable to believe that the course of interactions of large numbers of human beings would follow the same rules. There appear to be reasons relating to natural selection and survival that give an advantage to a chaotic system. It is more stable in the face of perturbation. A chaotic system simply shifts to some other track of the attractor. Chaos does not answer all questions, nor does it apply to all situations. There are some processes and systems that are simply not chaotic. Human behavior can be simply irrational or the system may be subject to influences that prevent chaos from occurring. It is, I believe, a useful tool for understanding and rationalizing the complex and dynamic situations that analysts in the intelligence community are often expected to present for decision or action.

Notes

1. Diana Richards, "Spatial Correlation Test for Chaotic Dynamics in Political Science," *American Journal of Political Science* 36, no.4 (November 1992): 1049. The author presents a simple chart showing the relationship between predictable and nonpredictable systems.

2. Gary Sick, *All Fall Down* (New York: Random House, 1985), 15. The book is a good general introduction to the fall of the Shah.

3. David H. Freedman, "Is Management Still a Science?" *Harvard Business Review* 70. (November/December 1992): 28

4. Steve Dickman. "Making Some Order out of Chaos: The Weather, Stock Markets, The Economy – Scientists are Puzzling Out Patterns in Highly Complex Systems," *Business Week*, 4 August 1986, 54. Processes as disparate as epileptic seizures and activity in hurricanes can be modeled using nonlinear mathematics.

5. Sharon Begley, "Finding Order in Disorder," *Newsweek*, 21 December 1987, 55. The author cites a number of examples, such as the comparison between the pattern of eye movements in schizophrenics and changes in lynx populations, that may be described using the mathematics of chaos and fractal systems.

6. Per Bak; Kan Chen, "Self-Organized Criticality," *Scientific American* (January 1991): 46.

7. Steven R. Mann, "Chaos Theory and Stategic Thought," *Parameters* (August 1992): 63. He did not suggest that these were the only factors, nor even that these had to be in the group. They do happen to work rather well for the problem in question, so I will stay with them.

8. Hal Gregersen, Lee Sailer, "Chaos Theory and its Implications for Social Science Research," *Human Relations* 46, no 7 (1993): 779. The authors propose two indicators of chaos in social systems. Bruce K. McGill, "Return to Chaos," *Quality Progress* 23, no 11 (November 1990): 56. The author suggests four features needed to "design and understand a process."

9. Mann, "Chaos Theory and Stategic Thought," 62.

10. Ibid., 63.

11. Ibid., 64.

12. Alexander Moens, "President Carter's Advisers and the Fall of the Shah," *Political Science Quarterly* 106, no 2 (Summer 1991): 211–37.

13. See chronology of Iran from 1941 to 1979, appendix A.

14. T.J. Cartwright, "Planning and Chaos Theory," *Journal of the American Planning Association* 57, no 1 (Winter 1991): 48.

15. James Gleick, *Chaos: Making a New Science*, (New York: Viking Press, 1987), 53-6 and inset after 114.

16. Gary Sick, *All Fall Down*, 35.

17. James P. Crutchfield, J. Doyne Farmer, Norman H. Packard, Robert S. Shaw, "Chaos," *Scientific American* 255 (1986): 49. The difference is between shooting one ball into a pocket and breaking the pack. Predicting exactly where each ball would end up when breaking a pack is not possible because of the number of variables, whereas many people are able with regularity to sink one ball in a given pocket.

18. Jan Stewart, "*Does Chaos Rule the Cosmos?*" 16–17.

19. Steven R. Mann, "Chaos Theory and Stategic Thought," 60.

20. Ibid., 60.

21. Hartmut Jurgens, Heinz-Otto Peitgen, Dietmar Saupe, "The Language of Fractals," *Scientifc American* (August 1990): 60.

22. Alvin M. Saperstein, "Chaos – A Model for the Outbreak of War," *Nature* 309 (24 May 1984): 303.

23. Diana Richards, "Spatial Correlation Test for Chaotic Dynamics in Political Science," 1047.

24. Michael J. Radzicki, "Institutional Dynamics, Deterministic Chaos, and Self-Organizing Systems," *Journal of Economic Issues* 24, no 1 (March 1990): 60. The author claims that all social systems consist of nonlinear relationships.

25. Hal Gregersen, Lee Sailer, "Chaos Theory and its Implications for Social Science Research," *Human Relations* 46, no 7 (1993): 777. As the authors state,"some social behavior is hard to predict because it is, in a sense, unpredictable and the underlying social systems are inherently chaotic."

26. T.J. Cartwright, *Planning and Chaos Theory*, 45.

27. Robert H. Waterman, "Strategy in a More Volatile World," *Fortune* 116, 21 December 1987, 181.