Perceptual Ambiguity and Trapping can Generate Inaccurate Assessments and Inappropriate Responses

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INTRODUCTION

This workshop has addressed the problems of assessment, evaluation, and crisis management in peace, humanitarian, and related types of operation. This paper provides an introductory description of how perceptual ambiguity and perceptual trapping may influence the ability to reach a consensus during assessment and evaluation of situations of interest. Failure to recognize the existence of ambiguous perceptions can lead to inaccurate assessments and the undertaking of actions that could be inappropriate and/or counterproductive. Use of models for the analysis of ambiguous situations based on the Normal distribution can introduce serious errors. Statistical catastrophe theory is an appropriate method for the analysis of ambiguous data. Such approaches can lead to the construction of response surfaces called perceptual landscapes that model the outcome of the assessment and evaluation processes. A further model based on catastrophe theory, outlined in the paper, illustrates how the media may influence the formation of perceptions and increase both the degree of political polarization and the level of conflict in previously non-adversarial situations.

Complex societal systems can exhibit chaotic behavior. The paper demonstrates how the emergence of such behavior can create significant problems for individuals involved in crisis management. Linear increases in the levels of key factors can cause a system exhibiting stationary state behavior to oscillate and then to become chaotic. Under such circumstances, actions taken to increase the level of control in an emerging conflict, could create new conditions where control becomes impossible due to the relative unresponsiveness of crisis management mechanisms. The challenge the analytic and operational communities remains the development of an appropriate level of understanding of the ways that the human mind generates and uses internal models of the external world.

AMBIGUITY OF PERCEPTION CAN GENERATE INAPPROPRIATE RESPONSES

There is significant evidence that sudden perceptual changes occur when individuals are examining political realities, and that different people can have different perceptions of the same situation (Woodcock, 2001, and Woodcock, Cobb, and Langendorf, 1993). Under some conditions, even very small items of additional information can cause a radical change in the way that the world is perceived. The fact that different analysts and others can report different perceptions of the same data or information can create very significant problems for those involved in the assessment and evaluation of the environments within which peace, humanitarian, and other types of operation can take place.

Studies with notional intelligence data, which are outlined below, have revealed that the same set of data can create perceptual ambiguities in the minds of skilled intelligence analysts. These findings point the way toward the development of new methods for assessment and evaluation of situations involving complex, and possibly ambiguous data and information. Failure to produce and use such methods could create situations where military and civilian entities might be asked to undertake inappropriate actions in potentially dangerous situations with minimal protection, for example.

THE NECKER CUBE CREATES PERCEPTUAL AMBIGUITY

A failure to assess 'correctly' the level of threat associated with a situation of interest can lead to inappropriate responses. Thus, assuming the existence of a low level of threat can lead to the deployment of lightly-armed troops who would be vulnerable to attack by a heavily armed adversary. The attack on United States forces in Somalia, in which the deaths of American soldiers created a political reality which led eventually to the withdrawal of US forces, shows what can happen when threat levels are underestimated. Overestimation of threat levels and the deployment of massive force can create situations in which groups that were relatively pacific may perceive that they are challenged, and react in a hostile manner in a situation that initially involved low threat levels.

In the Middle East, the Palestinians and Israelis each see the actions of their supporters as those of freedom fighters and those of their opponents as the actions of terrorists. The same actions have created completely different perceptions in the minds of the two adversaries. The Necker cube can serve as a metaphor for such situations (Figure 1). As you view the illustration, your perception appears to undergo a series of "jumps:" first the cube appears to be pointing out of the page, then it appears to be pointing into the page. One perception, with the cube appearing to point out of the page could be a metaphorical representation of a perceived freedom fighter. Another perception with the cube pointing into the page could serve as a metaphor for the actions of a terrorist, for example. In both these cases, the same overall information has created two radically different perceptions.

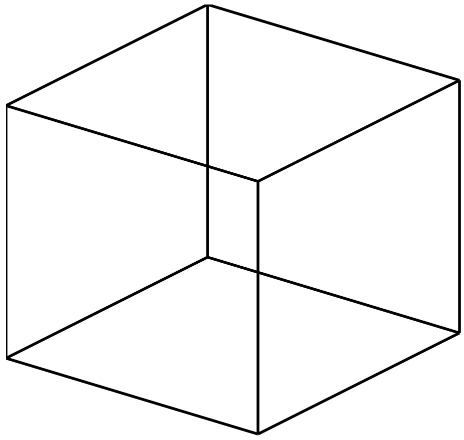

Figure 1: 'One Man's Terrorist is Another's Freedom Fighter!' The Necker cube illustrates perceptual ambiguity that can lead to differences in assessment and the undertaking of different and perhaps inappropriate courses of action.

The failure to be able to recognize the existence of a completely different, and equally valid, viewpoint constitutes a form of perceptual trapping. Each perceptually trapped individual would be incapable of understanding the views of others trapped in a different perception. Such trapped individual would be prevented from contributing to the interactions and negotiations needed to resolve conflicting situations. Release from the condition of perceptual trapping is a necessary requirement for such conflict resolving activities to be successful.

ANALYSTS CAN HAVE AMBIGUOUS PERCEPTIONS OF THREAT

Woodcock and his colleagues have investigated the ability of experienced intelligence analysts to identify threats associated with indications and warnings data involving the formation of a notional Soviet Operational Maneuver Group (OMG) (Woodcock, Cobb, and Langendorf, 1993; Cobb and Zacks, 1985). The studies demonstrated that perceptions of threat were neither linear nor uncorrelated in the minds of the military analysts involved in those studies. The analysts were enthusiastic about the technology and particularly interested in the capability of the system to identify inconsistent and/or ambiguous perceptions.

The analysts were also interested in the ability of the system to identify situations where small changes in input could give rise to either gradual or sudden perceptual changes under different conditions. The studies demonstrated that statistics based on the Normal distribution are suitable only for analyzing data that are clustered around a single peak value or mode. When data are not clustered around a single peak then analysis of those data with statistics based on the Normal distribution can introduce significant errors as illustrated below.

Figures 2a and 2b present illustrative results of a 'thought experiment' involving a notional threat assessment study where data are plotted as histograms. Results obtained from the actual study of ambiguous threat perception data are presented in Woodcock, Cobb, and Langendorf (1993). The height of each column represents the number of people perceiving the existence of a particular level of threat associated with a situation of interest. In one case, most people perceive the existence of a moderate level of threat (Figure 2a). By contrast, the assessment shown in Figure 2b reveals two relatively distinct perceptions. One sub-group of individuals perceives the existence of a moderate to high level of threat and another sub-group perceives a relatively low threat level to exist.

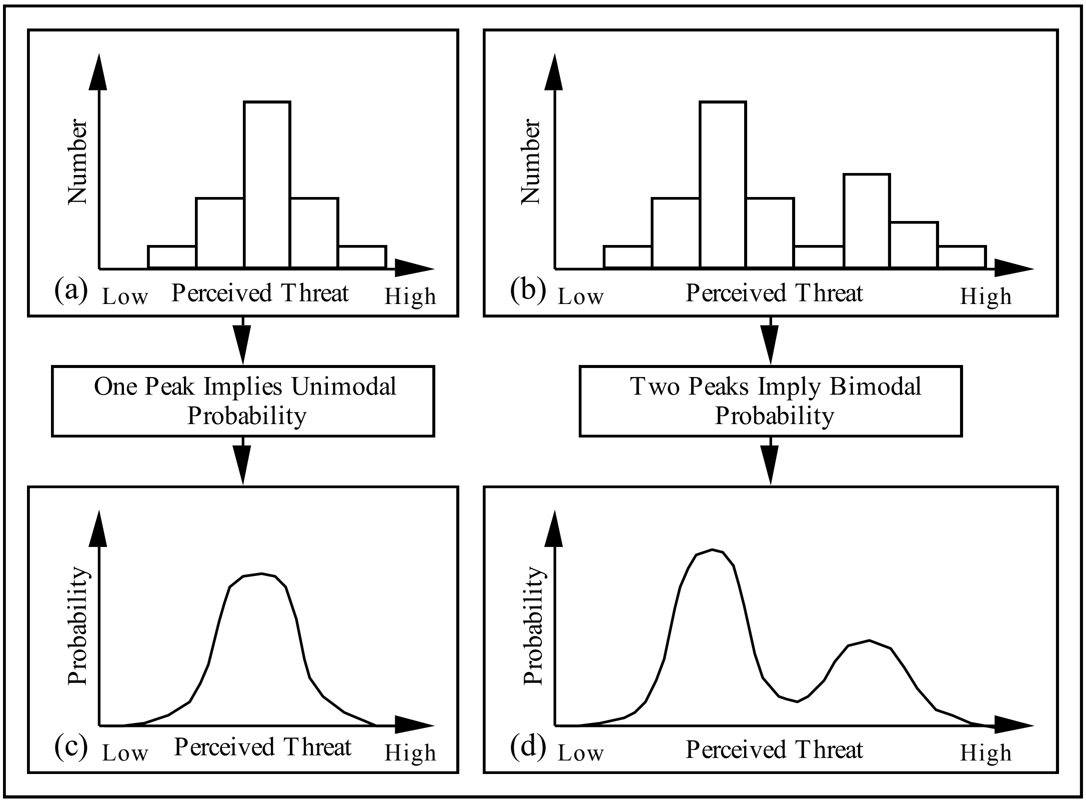

Figure 2: Notional data generated from a 'thought experimental' study of perceived threat levels. Unimodal and Bimodal probability distributions can represent the types of data shown in Figures 2a and 2b, respectively.

The shape of Figure 2a suggests that statistical analysis of the threat perception data could be carried out satisfactorily with the Normal distribution (Figure 2c). By contrast, analysis of the data shown in Figure 2b in the same manner would generate mean and variance values that would be highly misleading. The mean value of the data would fall somewhere between the two peaks in the distribution. The essential bi-modal nature of the data would be lost. Statistical catastrophe theory, which preserves the inherent bimodality of a set of data elements, would be more appropriate under those conditions (Figure 2d).

Tracking the changes with time in the levels of threat perceived by a group of individual analysts can provide a warning of the emergence of new challenges. Figure 3a indicates a predominant perception of low threat levels, with some individuals perceiving a higher threat level to exist at Time 1. Another assessment, taken at Time 2, suggests the existence of mixed signals in which the analysts report the conflicting existence of high and low threat conditions (Figure 3b). The analyst assessments at Time 3 indicate a high-threat condition (Figure 3c). Knowledge of such changes in perceived threat levels could provide valuable guidance to those involved in identifying and managing crises.

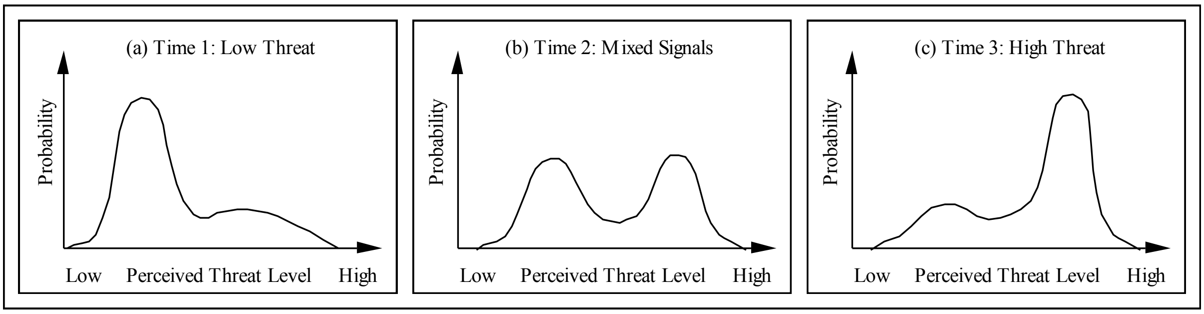

Figure 3: Changing perceptions can assist in identifying new and emerging threats

The processes used in the actual studies by Woodcock and Cobb are summarized in Figure 4. Sets of the unclassified notional indicators representing the formation of an OMG were presented in sequences to the analysts taking part in the studies. They were asked to assess the level of threat associated with each set of indicators by positioning a cursor on a line representing the spectrum of threat ranging from low (zero) to high (maximum) threat levels with the aid of the arrow keys on the computer keyboard. The threat perception data were collected and subjected to subsequent statistical analysis with processes based on both the Normal and Catastrophe distributions (Woodcock, Cobb, and Langendorf, 1993).

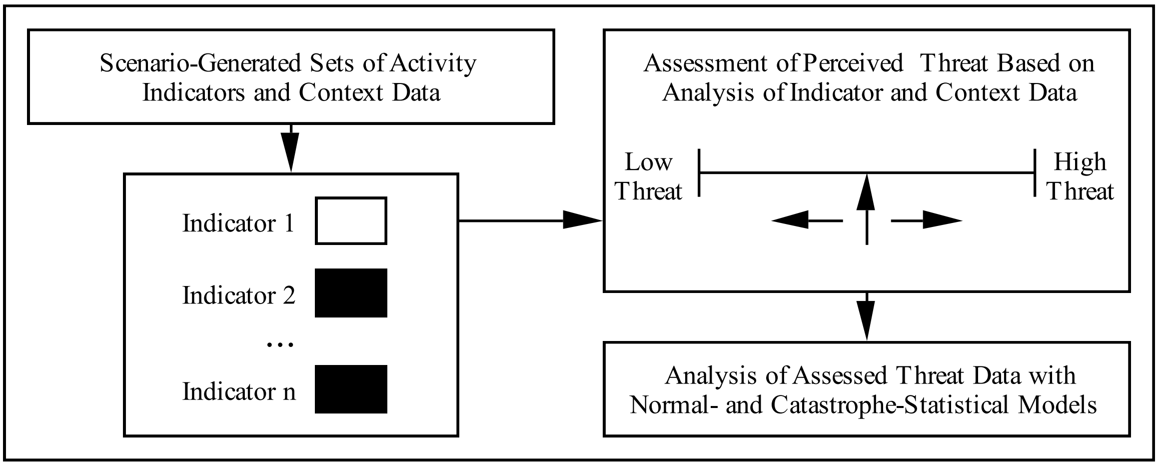

Figure 4: Sets of indicators have been used in threat assessment studies to generate threat perception data that were then analyzed with different statistical procedures.

Statistical analysis revealed the existence of perceptual ambiguity as well as phenomena defined as perceptual hysteresis and perceptual trapping by Woodcock. Figure 5 shows a response surface called the Threat Landscape that is typical of those that can be produced from analyst-generated threat assessment data. Positions on the landscape reflect vlaues of such input parameters as the number of active indicators and level of confidence. The layered structure explains why perceptual ambiguity can occur since it shows that two different perceptions can exist for the same data input conditions. The response surface shows how increasing the number of active indicators can create a sudden increase in perceived threat.

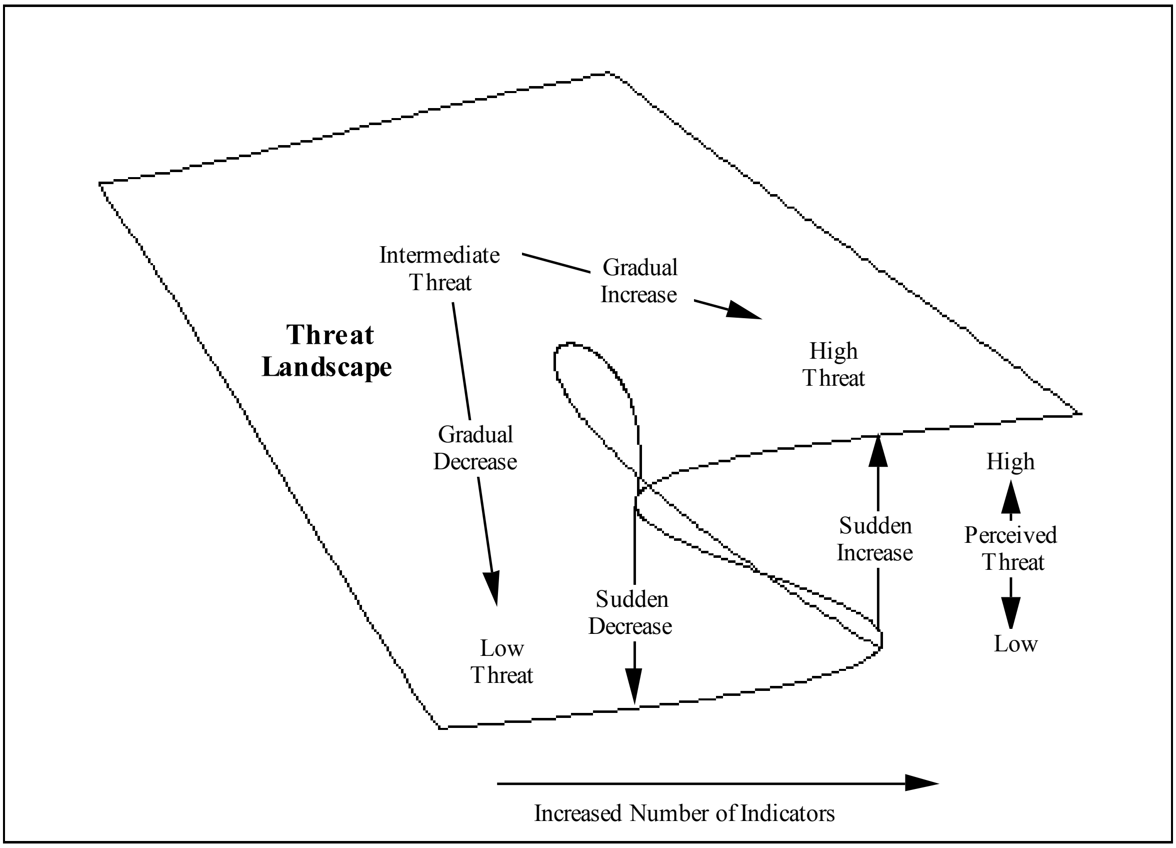

Figure 5: A Threat Landscape representation of analyst threat perceptions.

A decrease in the number of active indicators can lead to a sudden reduction in threat. Gradual increases or decreases in the levels of perceived threat can also occur, as shown in the Figure. A hysteresis cycle can occur as the number of active indicators increases and then decreases. Perceptual trapping takes place when large changes in the number of active indicators cannot change the level of perceived threat, for example. Perceptual trapping may explain why individuals appear unable or unwilling to change their views despite new evidence suggesting that those views had become untenable. Techniques used in the study of threat levels associated with a hostile military force could be used to study the threat associated with environments within which peace and humanitarian operations can take place. Identification of ambiguous threat assessments should trigger the need for the collection of the additional data needed to resolve such an ambiguity. Changes in the pattern of perceived threat could indicate the emergence of new challenges to entities and organizations involved in crisis management and related activities, for example.

INFORMATION WARFARE IS INVOLVED IN PERCEPTION MANAGEMENT

The media specialist and information warrior can provide ambiguous and misleading information that creates modified perceptions of the reality within which decisions are made and actions carried out (Woodcock, 2001). These influences can affect changes in the way that particular situations are perceived and handled. Creation of the illusion of high threat and great danger may have an inhibiting effect on policy and decision-making and the management of crises. Small changes in data elements, or skillfully-biased information repeated often enough, create their own reality. Thus, telling someone that the Necker cube (Figure 1) always points out, never permitting the belief that the cube may point inward serves as a metaphor for information warfare. Not only do the actions change the view of the world, they change the very way of thinking about the world and the process of making decisions. Information warfare creates significant new challenges for political and military leaders as well as new dimensions of the overall conflict environment.

As mentioned above, events in the Middle East have created conditions where both Israelis and Palestinians describe the actions of their adversaries as those of terrorists, while their own forces have the mantle of fighters for freedom. The perceived hatred of Kosovo Serbs for Albanians and Kosovo Albanians for Serbs, initially at an apparently low level were fanned by Milosevich and triggered open conflict. Such behavior can be illustrated at least notionally by a series of curves based on catastrophe theory and representing the level of political support for policies ranging from ‘left-wing’ to ‘right-wing’ (Figure 6). The model also shows how increases in the level of publicity or media involvement can transform a society characterised as mildly left-of-center into a highly politically polarised condition with well-defined opposition groups. In the example, the left-wing group is apparently able to dominate the right-wing group. Such polarisation can act as a conflict driver as previously co-existing differences of opinion become entrenched into extreme opposition positions. These changes create new political realities and the earlier co-existence of opinion might not be restored with ease as individuals and groups have become trapped by heightened rhetoric.

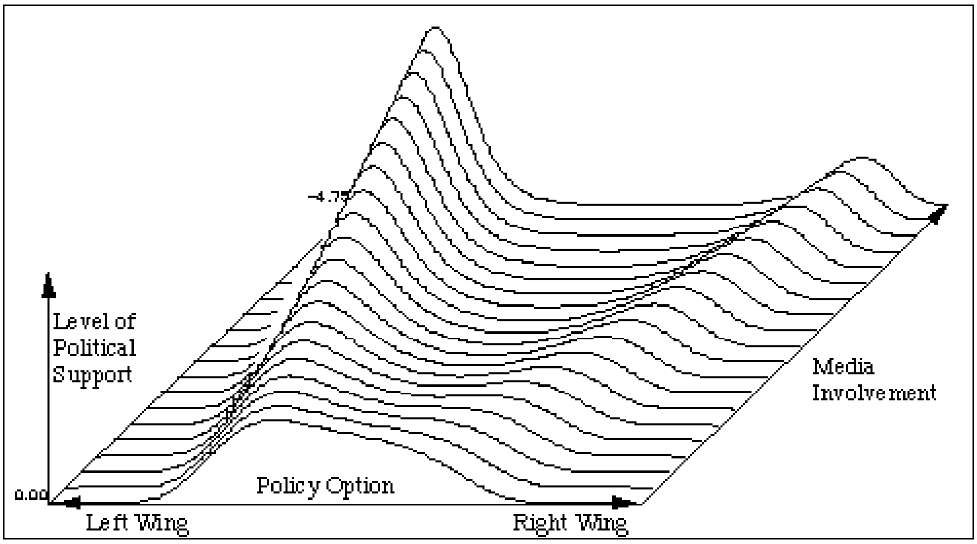

Figure 6: A simple public opinion model can illustrate the emergence of political polarization caused by high levels of media publicity (from: Woodcock, 2001).

CHAOTIC BEHAVIOR CREATES MAJOR CRISIS MANAGEMENT CHALLENGES

Models based on population dynamics have provided new insights into the nature of the processes responsible for the growth and interaction of military and insurgent forces and of the influences needed for their control (Woodcock and Dockery, 1989; Dockery and Woodcock, 1993). Such models can also be used to provide new insights into the problems created by the need to manage crises under chaotic conditions. When used to model societal processes, such models are referred to as societal dynamics models. Societal dynamics models can generate complex patterns of behavior and may exhibit stationary states, damped and sustained force strength oscillations, and chaotic behavior under different circumstances. The models have been investigated in computer experiments involving the generation of time series data and the undertaking of power spectral analysis (Woodcock and Cobb, 1990). Societal dynamics models form part of the basis for the Deployable Exercise Support (DEXES) System (Woodcock and Cobb, 1998; Woodcock, 1996 and 1995). Other models represent the response to a national government to the influx of refugees caused by a notional nuclear accident in a neighboring country (Uller and Woodcock, 1997), for example.

Some political leaders appear to act as if the world was flat and everything could increase forever. “Booms are good!” “busts are bad!” Such leaders also appear to be guided by a philosophy that could be loosely expressed as: if a five percent increase was good, a 10 percent increase would be better. Acting on such assumptions can be shortsighted, and may create dangerous, uncontrollable, conditions. Planners and decision-makers under such conditions face significant risks as what had been good, well-tested, strategies and tactics may actually become inappropriate and cause great damage (Woodcock, 2000).

The use of the model represented by the set of equations (1) and (2) illustrates what can happen when linear changes are made in inherently non-linear environments (Woodcock, 2001). The model calculates the size of two populations (represented by the dependent variables (x) and (y)) at a time (t) (represented by xn and yn, respectively). The growth of population (x) takes place in a density-dependent or logistic manner at a rate represented by the coefficient (m_1). Losses from that population are equal to the product of the strengths of the populations and the loss coefficient (m_2). Limits to growth are determined by the carrying capacity (c). Recruitment into the second population (y) occurs at a rate described by the recruitment coefficient (m_3) and losses occur at a rate described by the loss coefficient (m_4).

$$xn = m_1\, x\, (1 - x/c) - m_2\, x\, y \qquad (1)$$

$$yn = m_3\, m_2\, x\, y - m_4\, y \qquad (2)$$

Sample model behaviors are shown in Figure 7. When the growth coefficient, m_1, is set equal to 1.4, and the values of the other coefficients are set arbitrarily at $m_2 = 0.2$, $m_3 = 10.0$, $m_4 = 0.1$, and $c = 2.0$, population (x) follows an s-shaped growth curve to a maximum value of 2 units (Figure 7a). Increasing m_1 to 2.8 generates sustained oscillations in population size (Figure 7b). A further increase to $m_1 = 3.8$ produces chaotic oscillations (Figure 7c). These changes in behavior have critical implications for planners and decision-makers tasked with affecting changes in the system represented by equations (1) and (2) since exerting control under chaotic conditions can create severe, and even impossible challenges.

In particular, while the ability to respond in a timely manner to changing circumstances is relatively unimportant under steady state conditions (Figure 7a), the ability to respond rapidly becomes very important in oscillating conditions. In fact, in order to influence the behavior of such a system, it is necessary to respond in a time that is a sub-multiple of the peak-to-peak time of the oscillation (Figure 7b). The need for particular response time capabilities has significant implications for the architectures and capabilities of command

and control and crisis management systems and organizations. The need for faster response times can create significant personnel and equipment burdens since faster generally implies the need for increased cost and efficiency. The problems are increased under chaotic conditions where the peak-to-peak times vary from relatively short to relatively long intervals in an unpredictable manner (Figure 7c). Under some circumstances the emergence of chaotic conditions can prevent an organization with a relatively slow response time from exercising any influence over a system that had been controllable before the emergence of chaos.

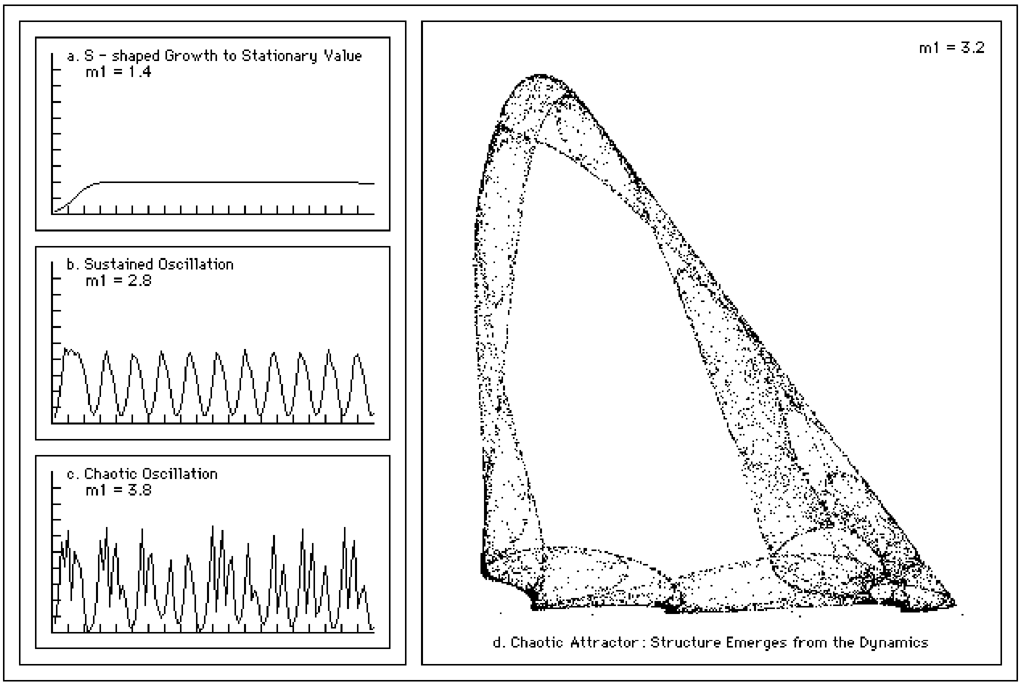

Figure 7: Equations (1) and (2) generate (a) s-shaped growth, (b) oscillations, and (c) chaotic behavior; (d) attractors are generated by plotting the simultaneous values of the dependent variables (x) and (y) (from: Woodcock, 2000).

Figure 7c is an attractor and represents the long-term behavior of the dynamical system described by equations (1) and (2). Inspection of the attractor reveals a complicated structure that has emerged from the dynamics of overall system behavior. The points in the figure represent the simultaneous values of the (x) and (y) parameters. It is clear that points have accumulated in some regions and are absent from other regions. Regions devoid of points represent inaccessible conditions for the system. Other research has shown that the attractor structures reflect the properties of entities called Critical Lines and Trapping Regions (Woodcock 1993a) and Possibility Zones (Woodcock, 1993b). Those entities indicate limits to the behavior of dynamical systems. Such limits may proscribe the ability of leaders to control events, and the implications of these findings are the subject of continuing research.

NEW HIGH FRONTIER: THE HUMAN MIND AND THE INTERNAL WORLD MODELS THAT IT CREATES

The new insights into the nature of perception on the one hand, and the behavior of dynamical systems on the other, described above, can provide part of the foundation of new models and theories to support the assessment, evaluation, and crisis management of situations of interest. In that context, the emerging post-post Cold War environment has created new challenges and confrontations as well as the prospect of new opportunities and collaborations with previous adversaries.

This new environment has produced circumstances where multi-dimensional interactions have replaced what were essentially two-dimensional interactions between NATO and its communist adversaries. New types of local and regional conflicts have gained world-wide attention as entities seek to gain advantages and create stability, or sometimes instability, to further their interests. Two of the most important conflicts, the drug war and the information war, have provided a new basis for conflict in the post-post Cold War era (Figure 8). The current war against terrorism, joined in earnest after September 11 2001, has aspects of both types of conflict since it appears that the proceeds from illicit drugs have been used, at least in part, to finance media and other forms of propaganda intended to support international terrorism.

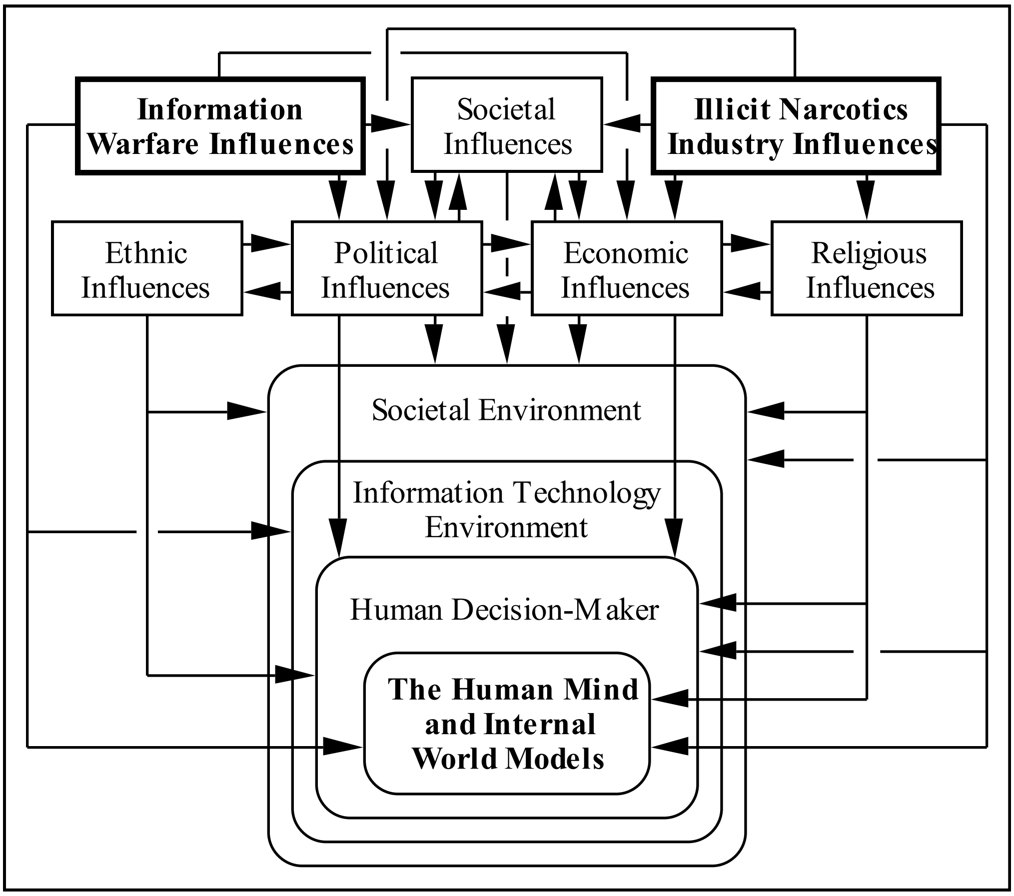

Figure 8: The way forward will need to support the development of an understanding of and the ways to counter the threats created by information warfare as well as the illicit narcotics industry and organized crime on societal stability and the ability of human decision-makers to function in highly complex, rapidly changing situations (from: Woodcock, 2001).

What is so often missed in discussions of information warfare is that the target is not the information itself, but rather the decision processes that the information supports (Dockery, 1995, for example). What is totally absent, even from the occasional reference to the centrality of the decision process, is an appreciation for the myriad ways the decision process may be influenced under a coordinated campaign that may include deception, physical destruction, intrusion, and even a form of “flanking.” In this latter case, access is sought by way of less protected components avoiding a direct frontal attack on a system of interest. Physical attack by computer viruses can take place, but even more subtle forms of attack are possible. Such attacks can involve the media and other processes that attempt to change perceptions of time, space, and external reality and the internal models that these perceptions create in the mind of an adversary. The goal of these activities is to channel actions in directions that are favorable to the information warrior without firing a shot.

Both of these wars are aimed ultimately at gaining control of what Woodcock (2001) has described as the *New High Frontier: The Human Mind and the Internal World Models that it creates* (Figure 8). The Drug War engages in conflict by chemical, psychological, and physiological challenges on the one hand, and economic, social, and other means on the other. The Information War involves creating ambiguity and uncertainty and forcing individuals to undertake inappropriate actions, or to take no action at all.

It is these internal world models that can give an adversary a critical advantage when they are developed and refined by extensive experience. Such models can capture the dynamical behavior of societal and other types of system. The level of understanding that this provides can be used to anticipate and forecast the behavior of others and guide proactive policy- and decision-making. Proactive actions can define the nature of the future conflict environment. Those actions can disrupt the acts, plans, and intentions of adversaries by getting inside their decision cycles and forcing them to react to the initial activity — creating situations in which it becomes vital to be first, partially correct, and survive not second, completely correct, and perhaps dead!

It is in this context that military and political leaders need to develop a rigorous understanding of the dynamics of those societal processes that they hope to manage or control. Failure to do so will create enormous risk for the nations and other organizations and entities that they have the honor and responsibility to serve. Models of perceptually ambiguous situations and chaotic soeietal process should have an important role in these activities.

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