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WAR IS THE STORM

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In 1992, Ohio State University professor Alan D. Beyerchen published one of the most important articles on Carl von Clausewitz's theory. The article identified aspects of chaos theory and nonlinearity in Clausewitz's greatest work, *On War*. The article's publication triggered a spate of further articles and books examining war through the lens of chaos theory—a swirling surge of truly innovative thought in strategic theory. However, this initial flurry did not last long, as strategic theorists became enamored first of the technophilic "revolution in military affairs" and then the post-9/11 focus on counterterrorism and counterinsurgency. Colin S. Gray, remarking on the subject in 2002, wrote that the debate had "lost the plot" by moving too far from a Clausewitzian concept of war, with some even claiming that chaos theory invalidated *On War*.[1]

Almost twenty years after Beyerchen, Antoine Bousquet picked up the torch in his book *The Scientific Way of Warfare: Order and Chaos on the Battlefields of Modernity*. Bousquet also sees complexity in *On War,* although he correctly identifies many of the metaphors the Prussian employed as being borrowed from thermodynamics. Then, in early 2020, Brian Cole persuasively argued in *Joint Force Quarterly* that Clausewitz's trinity is a depiction of a complex adaptive system.[2]

The debate thus far has revolved around these two poles: those seeking to integrate the new with the old (such as Bousquet and Cole), and others seeking to invalidate the old with the new. This article takes neither stance but instead inaugurates a third: the validation of the old with the new.

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To wit: Complexity theories indeed do apply to war, and Clausewitz's theories were the first to grapple with them.[3] The aim is not to disagree with the scholars mentioned above but to take the idea they addressed further. Subsequent advances in complexity science not only confirmed Beyerchen's assertions but have offered the opportunity to extend them. Bousquet affirmed Beyerchen but did not expand the discussion beyond the same basic assertion: that *On War* alludes to nonlinearity. Cole rightly identified the trinity as a complex adaptive system. War is nonlinear, and it was indeed Clausewitz who first identified that aspect. But the parallels between war and complexity science, and between complexity science and Clausewitz, do not stop with nonlinearity or the trinity. Clausewitz's theory of war does not just allude to complexity; rather, complexity is at its very core.

Indeed, war could be a branch of complexity science in its own right. Complexity sciences range across the study of adaptation and evolution, complex physical systems and complex adaptive systems, chaotic systems, networks, and information. All these not only are present in war but pervade it. Complex war studies would examine these subjects and explore the connections among them in the context of war and warfare.

In fact, every military organization—be it the formal armed forces of an established state, a band of rebels, or a dissident group of insurgents—is a complex adaptive system. The political systems these organizations serve also are complex adaptive systems. When two or more strategic actors engage in warfare through their armed forces, the result is a social phenomenon that shows a degree of chaotic behavior—war. This is not a new assertion; only the vocabulary is—relatively—new. It was Clausewitz who first identified these aspects of the nature of war. It is only with the advent of the complexity sciences in the twenty-first century that we truly can understand the prescience of the nineteenth-century Prussian thinker.

This article will present an (admittedly brief) introduction to the subject of complexity science and chaos theory. Next examined will be its applicability to war. The core of the article then follows, providing an examination of Clausewitz's theory of war through the lens of complexity science, focusing on Clausewitzian concepts that find analogues in the complexity sciences. Having established the viability of complex war studies and the Clausewitzian framework as the earliest attempt to grapple with war as a complex system, the article closes with a number of implications and conclusions drawn from a Clausewitzian paradigm of war as a complex system.

This has several ramifications for the future of war, strategy, and strategic theory. As prescient as Clausewitz was in identifying complexity in war nearly two centuries ahead of scientists, complexity science offers a path further forward,

not only for developing a better understanding of Clausewitz's theory of war but toward better ways of applying it in practice. Current debates about attrition versus maneuver-based approaches, the operational level of war, and so-called gray-zone operations all can be informed better by an understanding of Clausewitz's theories viewed through the lens of complexity.

WHAT IS COMPLEXITY?

Although complexity science is new, everyone is familiar with complex phenomena, since everyone on Earth constantly is surrounded by a major one: the weather. Weather events are used frequently to explain and demonstrate aspects of complexity science such as order and disorder, or predictability and unpredictability. An orderly weather system can become disorderly at a moment's notice, as any mariner knows. The mariner also knows that the particular occurrence of a storm cannot be predicted, but he can predict with certainty that a storm will occur again sometime, somewhere. As the storm, so too is war.

The field of complexity studies is vast, so only a brief description of its most salient areas is possible here. The discoveries that created this new science were made by cross-disciplinary academic research that revealed connections among such fields of study as physics and economics, chemistry and climate, and genetics and geopolitics. The study of complexity is the study of these connections. Physicist Neil F. Johnson defines *complexity* as "the phenomena which emerge from a collection of interacting objects."[4] It perhaps is not surprising that viewing war through the lens of complexity can yield valuable insights.

One area of complexity science that is particularly relevant to war is complex adaptive systems. Examples of complex adaptive systems include cities, corporations, infrastructure elements such as power grids, swarms (biological or mechanical), brains, immune systems, the language used to write this article, and the digital network used to transmit it for publication and consumption.

The study of complex adaptive systems is new enough that a comprehensive framework remains to be divined sometime in the future, but these systems share a few characteristics that can be considered definitional. The first is that they are *nonlinear,* in the sense that the aggregation of their components by simple addition does not capture their essence; their whole is greater than the sum of their parts. Second, complex adaptive systems *self-organize;* they usually lack a central director or operate with little or no central direction. Third, most display *chaotic behavior;* more on that below. Fourth, they adapt on the basis of interaction with their environments, a process called *adaptive interaction*. Lastly, they display *emergence:* unpredictable actions or reactions produced by their adaptive behavior.[5]

In addition to these common characteristics, complex adaptive systems have common aspects. The first common aspect is agents. *Agents* are individual actors

that make up the system and its behavior but also learn and adapt as individual components. Blood cells, synapses, ants, birds, markets, investors, departments of corporations, and power substations all are agents in complex adaptive systems. Importantly, learning, adapting, acting, and reacting on the part of agents are not always optimal or even rational. Lastly, particularly sophisticated agents have the ability to hypothesize about the future.[6]

It is the ability of the agents that compose complex adaptive systems to act and react to their environment that produces emergence. On the basis of feedback from agents' environments and other agents, adaptations, behaviors, and order emerge. The classic example is ants. Individual ants act and react on the basis of feedback from the environment and other ants, producing collective behaviors on the part of the entire colony such as defensive swarming and nest construction. These collective behaviors emerge from the aggregate actions of individual agents. As mentioned above, more-sophisticated agents such as human beings adapt not just on the basis of feedback but also by developing hypotheses about the future that rely on memory of previous adaptations and pattern recognition.

Another common aspect is boundaries. Boundaries exist among internal components and between the system and its external environment. No complex adaptive system is infinite, and the existence of boundaries enables system definition and analysis. The boundary of a city's traffic-control system, to use a common example, is the legal boundary of that city. Examples of boundaries are myriad, but the important thing is that boundaries are semipermeable and can shift. If the city incorporates neighboring territory, the boundaries of its traffic-control system expand and the new space offers new opportunities for adaptation. The emergence of new actions or strategies available to the complex adaptive system usually is connected with such boundary shifts.[7]

Lastly, complex adaptive systems display lever points (also known as attractors or strange attractors). Although such systems usually are very resistant to external pressure and react to it in unpredictable ways, a small input against a lever point yields a change in the behavior of the whole system that is unpredictable in magnitude, direction, or both.[8] Step on an ant away from the nest and the colony will not even notice; disturb the nest and threaten the queen, however, and the colony will defend itself and begin rebuilding.

Lever points are aspects of deterministic, nonlinear systems where inputs yield drastic and rapid change in the behavior of the system. They are structures of order within disorder, patterns toward which a chaotic system generally tends, given enough time or iterations. Hence the name *attractors;* it is as if the system is attracted to the pattern. No hurricane is the same as another, but all hurricanes are instantly recognizable because they are generally similar in shape.

Thus, complex adaptive systems are systems that demonstrate perpetual novelty and recurring patterns, predictability and unpredictability, order and chaos simultaneously. This makes them exceedingly difficult to analyze and understand, but their ubiquity and wide applicability make the effort worthwhile.

The nonlinearity of complex systems must be stressed: "A nonlinear system will show a disproportionate response" to stimulus or inputs. In a linear system, the proportionality of a response makes it predictable, and an input will yield a proportional output every time. In a nonlinear system, the disproportionality of the response makes it unpredictable; the same input may produce a different outcome at a different time.[9] Complex adaptive systems, because they adapt and react, also display this form of nonlinearity.

Some complex systems are also chaotic. *Chaos* is a specific type of nonlinearity; chaotic systems are those "in which even minuscule uncertainties in measurements of initial position and momentum can result in huge errors in long-term predictions of these quantities." This unpredictability is the major defining trait of chaotic systems. It results from "sensitive dependence on initial conditions," and systems that display this sensitivity are referred to as *deterministic*. The course and shape of a chaotic system are so determined by initial conditions that any small difference from one iteration to another can cause large-scale differences in subsequent behavior.[10] Note that the word *deterministic,* in this sense, does not mean predetermined, or that chance and probability are absent.

This is not the same as saying that the behavior of a chaotic system is random; it is not. Chaotic systems are bounded and self-similar, or fractal. A self-similar or fractal system will display repeated patterns that, given enough time, will be similar but not identical; however, it will do so at unpredictable times and rates. Yet despite these systems' ultimately unpredictable nature, patterns exist. These patterns occur within boundaries, but not outside them.[11] The limits and patterns of a chaotic system give it a unique but recognizable shape.[12]

Importantly, a chaotic system, because it is nonlinear, cannot be understood or predicted by breaking that system down into its constituent parts, as a linear system can be. It is greater than the sum of its parts; its parts must be seen as a whole.

For example, the internal structure of a cloud is chaotic. Clouds have fuzzy but definite boundaries, end points at which the aggregate is no longer a cloud but another system. There is the cloud, and then there is the air (which is another chaotic system) around it; however, while the separation between the two is definite and obvious at the macro level, it is not identifiable at the individual-part level. This sounds complicated—and it is—but clouds are not difficult to identify when viewed as a whole—even a child can do it. Should the boundary of the cloud shift, however, it can become something else, such as fog.

As noted previously, perhaps the most common example of a chaotic system is the weather. This is sometimes mentioned alongside the *butterfly effect,* a concept that captures the nonlinear aspect of chaotic systems. A butterfly flapping its wings in one place may disproportionately cause a hurricane in another—or it may not. Weather is unpredictable, in the sense that we never can know when or exactly where the next hurricane will occur, but it also is predictable in the sense that we know hurricanes will occur somewhere, sometime. There is predictability and unpredictability at once.

This is the nature of complex adaptive systems. They are unpredictable, yet they display self-similar patterns, even if the timing by which those patterns play out may be unpredictable. They are disorderly and yet orderly. They are complex in some ways and simple in others. This synthesis of seemingly antithetical aspects is in their very nature. Such systems are more complicated than can be presented here, and the field of study, while new, is already vast. However, these basics suffice for the goals of this article. We will return to these concepts later, but for now it is necessary only to understand how they appear in war.

IS WAR COMPLEX?

Whether derived from a Clausewitzian framework or not, an awareness has been growing that war and strategy should be viewed as complex in the scientific sense. Colin Gray, for example, has written that strategy is complex and that it is "nonlinear in that consequences, or effectiveness, can show radical discontinuities." He goes on to write that strategy also is chaotic, as "it can register both the radical discontinuities in outcomes characteristic of nonlinearity, as well as consequences that differ on a range apparently wholly disproportionate to the scale of the initial impetus."[13]

These concepts are rooted in math and physics. So while general similarities between war and complexity science can be identified, there also should be underlying quantifiable evidence. Such evidence has been found, for instance, in the identification of *power laws* (functional relationships between two quantities) that apply to combat. Lewis Fry Richardson analyzed casualty figures for wars occurring between 1820 and 1945 and found that the relationship between the number of wars and the number of casualties did not follow a normal statistical distribution but rather a power law that when graphed produced a straight line; as casualties increased, the total number of wars decreased. One would expect a bell curve in which there would be a low number of wars with low casualties, a high number of wars with average casualties, and then a low number of wars with high casualties. But this is not the case; wars with fewer casualties are the most frequent, while wars with higher casualties are very rare. Despite a massive amount of geopolitical disorder and technological change over the period

studied, the underlying mathematical pattern in terms of casualties demonstrated predictable order.[14]

This same mathematical power law has been found to apply to the internal structure of a number of individual armed conflicts. University of New Mexico scholars Aaron Clauset and Maxwell Young found that the same law that Richardson propounded applies to casualties per terrorist attack. Another team of researchers found that the same law applies to casualties within wars, not just across wars, by analyzing casualty figures from conflicts in both Colombia and Iraq.[15] That such vastly different wars—from the massive industrial conflicts of World Wars I and II to terrorism and low-intensity insurgencies—all demonstrate a singular mathematical pattern defies conventional wisdom.

This tells us that complexity applies to war at a deep, foundational level, to war as a phenomenon, and that viewing war through the lens of complexity and chaos can yield insights into its nature and character. More-recent developments in complexity science offer still more insights into war as a complex phenomenon. The idea of complex adaptive social systems is one particularly rich area of research.

Military Organizations as Complex Adaptive Social Systems

Determining whether complexity science applies to war hinges on its interactivity. War is complicated, immensely so, but that in and of itself does not mean it is scientifically complex. The interactivity of war is inherent in the engagement by two strategic actors in organized violence for political ends. War becomes a subject for complexity when we recognize that the strategic actors themselves are complex adaptive systems, be they nations, ethnic groups, religious communities, insurgents, or terrorist organizations. More specifically, they are complex adaptive social systems.[16]

Complex adaptive social systems encompass human organizations of all sorts, from governments and social movements to charitable organizations to flash mobs, from small businesses to international corporations, criminal organizations, terrorist networks, and, of course, military organizations. Formal military forces such as armies, navies, and air forces, as well as informal ones such as insurgent groups, display all the characteristics of complex adaptive systems, including nonlinearity.

This may seem a strange assertion, given that most military organizations prefer neat, linear chains of command, but the nonlinearity that military forces display is nonadditive. Orders of battle can be drawn up and the number of combatants on each side calculated and tabulated, but that will offer little insight into the two sides' true capabilities. Two opposing battalions of seven hundred people each may have vastly different levels of training, morale, fitness, experience, cohesion, and other intangible qualities that will affect their performance in combat. Nor can a battalion simply be viewed as three companies; merely putting seven hundred people together does not a cohesive, combat-effective battalion

make. Three companies that never have trained or fought together as a battalion will struggle to do so, while three companies that have done so will not. When it comes to the agents of military complex adaptive systems, sums frequently are greater or lesser than their parts. Furthermore, hierarchical organizations are a typical characteristic of complex adaptive systems. The military structure of companies, battalions, regiments or brigades, divisions, and corps, used by nearly every modern military, emerged from continual interaction among military forces in the premodern era. Navies undergo this same process of adversarial feedback that produces similar structures; for example, the classification of ship types is universal across different navies.

Military forces also self-organize. Few militaries operate as disorganized masses; even guerrillas organize into cells and teams that adopt specialized functions. Well-developed militaries indeed may have their organization codified in doctrine or even law, but that organization originally was, and still may be, influenced by the agents themselves as they seek competitive advantages over opposing agents. They may do so even over other agents within the same system—both interservice and intraservice competition is fierce.

Boundaries and lever points also are seen in military forces. In a military context, agents are units and the individuals that make them up. The boundaries between what is *civilian* and what is *military,* and who is *a civilian* and who is *a servicemember,* are relatively clear—but also semipermeable. And militaries refer to lever points variously as *main efforts,* as *critical capabilities* or *critical vulnerabilities,* or, more properly, as *centers of gravity.*

That militaries display a lack of central direction is the most counterintuitive aspect, as nearly all military forces do have central direction—at least in theory. Yet although political and strategic decisions ideally flow down from the very top of the chain of command, in practice it is impossible to achieve total, central direction over human beings, especially those engaged in warfare. Even conscripts will engage in decision-making at the tactical edge, perhaps simply whether to fight or flee. No matter the authority of a king, emperor, president, or general, no soldier is an automaton. Individual units and commanders, down to the commanded, have freedom of action to make decisions, to a greater or lesser degree. Total, centralized control of human beings is impossible.

Since militaries are composed of thinking, feeling, fearing, and reacting humans, military agents lack total central direction and adapt to their operational environments. Humans remain stubbornly unpredictable, no matter how regimented and disciplined their existence, and yet still they display order, organization, and commonality. Combined into units in which both collective success and individual survival depend on outcompeting other agents, military forces naturally adapt and evolve in response to the brutal natural selection of combat.

It is through this constant action and reaction, adaptation and evolution, interactivity and innovation that more-advanced and -sophisticated forms of military organization and tactics emerge, seemingly—but never actually—from nowhere. This emergence is the final characteristic of complex adaptive systems. From the Greek phalanx, the Roman legion, the Frankish knights, the Mongol horde, the Spanish *tercio,* the British fleet, the French *corps d'armée,* and the German panzer corps to the U.S. Marine Corps (USMC) Marine air-ground task force, tactics, technology, and organizational combinations and recombinations emerge in a never-ending contest of survival of the fittest. Strategy and strategies emerge from the tactical adaptations of the agents involved. Helmuth von Moltke the Elder, who said that *strategy* is a "system of expedients," just as well might have said that strategy is emergent.[17]

War at the Edge of Chaos

Military forces themselves are not war. Complex adaptive systems have some direction, some control over themselves. But neither side controls a war; both are locked into a phenomenon above and beyond themselves. Just as chaos is a specific type of complexity, war is a specific type of international competition between states. For war to be complex and chaotic, as a whole it must demonstrate the characteristics of a chaotic system. For war to be considered chaotic in the scientific sense, it must be deterministic and nonlinear. It meets both these requirements. War, or more specifically *a* war, is a chaotic system produced by the dynamic competition between two (or more) complex adaptive systems, a clash of passion and hatred, probability and chance—a system that, despite the chaos, is yet subordinate to rational direction. These characteristics mean that the system is not fully chaotic but rather resides at the edge of chaos, where dynamic interactions are never in equilibrium but also never completely random. War so clearly exists in this space that scientists borrow the language of war to describe the space itself: "The edge of chaos is the constantly shifting battle zone between stagnation and anarchy."[18]

War is deterministic because it is sensitive to initial conditions, and these conditions are inherently political. For a war to occur, it must meet three initial conditions:

- *There must be political interaction between two or more actors.* Without such interaction of some kind (e.g., diplomatic communication, trade) there can be no conflict between the political actors.[19] Without political interaction, the political actors will not even be aware of each other's existence and thus will experience no political conflict.
- *There must be a political conflict manifested in the divergent goals of the actors involved.* If two political entities are engaged in political intercourse but do not disagree, there will be no war between them.

- *There must be a willingness to employ political violence or the threat thereof on both sides.* Political entities can, and frequently do, resolve political conflicts nonviolently, through some combination of diplomatic, economic, and informational means. A political conflict becomes a war only upon the introduction of *political violence* (i.e., organized violence for political purposes). It does not follow necessarily that other means of political intercourse, such as diplomacy, cease, merely that violence becomes one of the means employed.

If any of these conditions is absent, there will be no war between two political entities. There is no possibility of conflict or violence if they do not interact; there is no reason for violence if there is no conflict; and if there is no willingness *on both sides* to employ violence, the conflict will be resolved through other means. If there is willingness to employ violence on one side but not the other, the latter side will submit. War moves from a possibility or a threat to an actuality once organized violence is employed.

These are the initial conditions that create a war and to which it is sensitively dependent; they continually interact, reinforce, and subsume each other. Since neither side knows just how much violence the other side is willing to inflict and endure, and neither side knows just how dearly held the political goal of the opponent that created the conflict is, neither side can predict with certainty what it will take to make the other submit. As a war goes on, these factors change depending on the course of events, further reinforcing that uncertainty. But how and how much these factors change depend on their initial state; if that had been different, they would have produced a different war or no war at all.

Whether war is nonlinear does not depend on the form of combat that occurs. Sometimes war is described as linear if it involves clear and distinct lines on the ground between uniformed troops and nonlinear if it does not, such as in guerrilla warfare. But recall that *nonlinear* in this sense means nonproportionality and nonadditivity, not the lack of defined lines. A nonlinear system displays nonproportionality and nonadditivity.[20] The butterfly effect is, of course, present in war as well. A private firing a bullet that strikes the right person, such as an opposing general, or snapping a picture that captures evidence of a war crime can have an outsize and unpredictable strategic effect on the entire war. A single Serbian terrorist in Sarajevo in 1914 can ignite the world over lunch.

Nonproportionality means that any output of the system is not necessarily proportional to the input that produced it. In a linear system, there is a predictable, repeatable relationship between inputs and outputs. *Additivity* means that a system is the sum of its parts, and thus can be broken down into those parts because they are not dependent on their interactions for meaning. *Nonadditivity* means that the parts of the whole are dependent on mutual interaction. A scientific example of nonlinearity is the three-body problem. This problem in physics refers to a system

with three or more mutually interactive parts. Since a system with three or more parts becomes nonlinear, the trajectory of the input becomes unpredictable—that is, chaotic. The classic illustration of the concept is a pendulum suspended among three magnets. Once let go or otherwise provided with an input of energy, the pendulum will swing in a chaotic, unpredictable trajectory as the three magnets exert force on the pendulum. As we shall see, this very example, employed in many works on complexity and chaos, also is employed by Clausewitz.

Despite this, war as a phenomenon is more akin to climate. Tension always exists among strategic actors, even friendly ones; each pursues its policies via nonviolent means affected by the vagaries of chance and contingency. International relations fluctuate through highs and lows, sunshine and clouds, deluges and droughts of competition and jockeying. At times, though, the passions of fear, honor, and interest combine to form a storm system. War is the storm.

A storm is a combination of the factors of barometric pressure, humidity, winds, precipitation, and the like. All these components are ever present in the atmosphere, and all interact constantly. Sometimes the combination produces storms, of varying intensity up to hurricanes. Fronts form, clash, and push against one another, wrestling until one dominates the other.

Political conflict is similar in more than just grammar. The components of war, all of which are political in nature, interact normally much of the time. Politicians, diplomats, media and economic organizations, and even military forces constantly interact during peacetime. Sometimes, however, the political pressures interact such that they produce a new phenomenon—war—that behaves in a chaotic way.

HOW DO COMPLEXITY AND CHAOS MANIFEST IN *ON WAR*?

That Clausewitz leaped ahead of other theorists before and after his time was an accomplishment enabled by his own innate talents; his lifelong exposure to war in practice; his study of war in theory; the mentorship of Gerhard von Scharnhorst and other learned advisers; and the assistance of the prodigious intellectual abilities of his wife, Marie von Clausewitz.[21] From this confluence of factors emerged a timeless theory.

Beyerchen, Bousquet, and Cole already have identified parallels among chaos theory, complexity science, and *On War*. Identifying passages in the book that illustrate these parallels is important, but I argue that Clausewitz's entire framework—not just some concepts, but the way those concepts fit together as a whole—constitutes a theory of war as a complex system. This finding is quite easy to miss if his concepts are extracted from the framework and examined in isolation. But studying how the subcomponents of his theory relate to each other reveals its fundamentally complex nature.

Clausewitz himself implored us to view war as a *gestalt*—an organized whole that is more than the sum of its parts—and his theory should be viewed the same way. Physics professor and complexity expert Neil Johnson has written that the key to complexity is to view phenomena holistically rather than through reductionist analysis.[22] Clausewitz's theory is timeless because he approached the phenomenon of war through just such a holistic lens. The very first paragraph of *On War* stresses this viewpoint: "But it is necessary for us to commence with a glance at the nature of the whole, because it is particularly necessary that in the consideration of any of the parts their relation to the whole should be kept constantly in view."[23]

All the boundaries described above that define the parameters of war as a chaotic system are derived from Clausewitz's definition of *war:* "War is only a continuation of State policy by other means." These boundaries are necessary to understand what war is and, just as importantly, what it is not. They also help us understand war's unpredictability. Since neither side knows just how much violence the other side is willing to inflict and endure and neither side knows just how dearly held is the political goal of the opponent that created the conflict, neither side can predict with real certainty what it will take to make the other submit. As a war goes on, these factors change depending on the course of events, further reinforcing that uncertainty. Additionally, it was Clausewitz who wrote one of the earliest depictions of the butterfly effect, the famous analogy for nonlinearity: "We see that here, also, the result cannot be determined from general grounds; the individual causes, which no one knows who is not on the spot, and many of a moral nature which are never heard of, even the smallest traits and accidents, which only appear in history as anecdotes, are often decisive."[24] This quote is from a section entitled "Overthrow of the Enemy" where Clausewitz is arguing that even the smallest event can have disproportionate effects on the outcome. In fact, *On War* as a whole lacks easy, linear concepts of warfare, although this is not well known. Sir Hew Strachan has argued recently that the Howard/Paret translation of *On War* injected a hierarchical, linear conception of ends and means that is not reflected in the original text.[25] An examination of how Clausewitzian concepts interact with each other, drawing out connections Clausewitz made among them in *On War,* reveals the inherent complexity of the work.

The Trinity

As mentioned above, Brian Cole has argued convincingly that Clausewitz's trinity depicts a complex adaptive system. Clausewitz's trinity provides us with the initial conditions of a war, which change in unpredictable ways as the war goes on. The trinity, which is the culmination of chapter 1 of book 1, is composed of one pole that is "hatred and animosity," one that is "the play of probabilities and chance," and one that is "the subordinate nature of a political instrument."[26] The

first is an irrational force, the second is nonrational, and the third is rational.[27] These three forces are expressed and exerted in the physical realm by three political forces. The civilian population of a political entity will exert pressure mostly (but not exclusively) through passion, hatred, and enmity, and as a result supporting the war, not supporting the war, or supporting / not supporting it with varying degrees of enthusiasm. The military forces engaged in combat are most concerned with probability and chance; can they defeat the opposing forces? With what probability? It is, after all, primarily their lives on the line, giving them a visceral interest in success. Lastly, war's rational subordination to policy is mostly the domain of policy makers and political leaders such as kings, legislators, and presidents, whose political goals are tied up in the conflict. This "real world" trinity often is referred to as Clausewitz's secondary trinity.

The course and character of a war are determined by the exertion of these three forces. But the relationships are never static; the poles constantly exert a gravitational force on the war, and because they are opposed the result is nonlinear and unpredictable. A push in one direction may not produce an equal and opposite reaction, since the other poles also are exerting forces. War releases societal forces that can be neither predicted nor controlled.

To return to the metaphor of a pendulum suspended among three magnets, the course of the pendulum (once the war begins) is determined by its position in relation to the three magnets when it is let go. This is its sensitivity to initial conditions. The subsequent course of the pendulum (and the course of the war) is determined by the forces exerted by the three magnets (the trinity), making it nonlinear, and increasingly unpredictable as time goes on. Moreover, this three-body problem exists on both sides, not just one, making war a six-body problem at least and a many-body problem in most cases.

These forces all exist outside the system of war as well; they all have their meanings outside the system. However, the meaning of the combination within the system is different. Their relationship changes. When added together as a whole, their unpredictable interactivity creates a unique system above and beyond its constituent parts—war.

War and Warfare

Although the difference between war and warfare is not one of Clausewitz's dichotomies, it is used here as shorthand for Clausewitz's differentiation of war's *nature* (war) and war's *character* (warfare). As captured in his famous metaphorical comparison to the chameleon, war's *nature* is timeless and never changing, but its *character*—its expression in practice—always changes. This union of continuity and long-term adaptation is what complexity science theorist John H. Holland refers to as a two-tiered theory. A similar two-tiered structure exists in all complex adaptive systems.[28] This was not a matter of Clausewitz refusing to take

a side in a debate about whether war ever changes; rather, it was Clausewitz's way of dismissing such a debate entirely. Far before the development of chaos theory, Clausewitz recognized not only that continuity and change could coexist but that they do, and must, coexist in war.

War demonstrates this. War's nature as a political phenomenon endures; its expression, however, takes on a multitude of forms. War always may be about achieving political power, but it also can be about having and exercising the political power to impose a preferred religion, to extract profit or resources, to achieve vengeance, to preempt a possible threat, to exterminate a rival, or to carry out any number of other vices.

There is even continuity in combat itself. Even as the technology and methods of violence change, the human element of combat—the impact of danger, including the fear, courage, and other emotions experienced in response to it—remains always a factor. The surprise ambush is a tactic that likely is older than written language, but it remains devastatingly effective on the battlefield today.

The implications for strategic theory of this synthesis are profound. Rather than pinning his conception to an impossible level of certainty, à la the Jominis of the world, or giving in to strategic nihilism, à la Georg Heinrich von Berenhorst (the Prussian military officer and contemporary of Clausewitz who believed that war is so unpredictable that no form of planning or analysis is even possible), Clausewitz created space for both to coexist.[29] A Clausewitzian is thus forewarned against cries of both "everything has changed" and "nothing has changed," for neither is ever true.

Ends and Means

War's identity as a chaotic system has vast implications for the relationship between its ends and its means. The nonlinearity of mathematical chaos systems frequently is described in terms of *inputs* and *outputs,* but in strategic theory these commonly are called *means* (inputs) and *ends* (outputs). The relationship between the two is inherently nonlinear. As noted above, Sir Hew Strachan argues that Clausewitz's conception of their relationship is nonlinear, despite later translations that present ends and means as a linear hierarchy.

The most common description of the relationship is the Lykke model of ends, ways, and means. The Lykke model is a strategic process developed by U.S. Army War College professor Colonel Arthur F. Lykke Jr. in the 1980s.[30] The basic idea is that victory can be achieved by aligning means (military forces) and ways (campaigns, battles, tactics, etc.) with ends (the political goal), enabling the achievement of that goal. There are two problems with this concept. It ignores the interactivity with the opponent; and it assumes a linear relationship between ends and means, as well as ways, in war. Use of the word *align* itself betrays the assumption of linearity. But if war is a nonlinear system, the relationship cannot be so.

Clausewitz addresses the relationship between ends and means in war, viewed properly as a nonlinear system, immediately after his presentation of war itself as nonlinear. Clausewitz stresses here that the nature of war dominates the relationship between ends and means, and quickly points out that their interactivity means that the opponent's will is a central force.[31] This chapter is full of qualifications. Clausewitz states that, logically, both combatants should fight to achieve their ends until their means are totally exhausted. But this rarely occurs in practice; most wars end somewhere prior to that point. This is because the ends determine the means, and the will to achieve those ends determines the level of commitment on each side. Means, however, also interact with ends, as few political actors will strive for ends that clearly are beyond their means, except in desperation. At the same time, they never can know truly whether their means will stack up to their ends. Even a decision by one side to apply means in a certain way can force the other side to apply them in a certain way—against its will. The entire chapter is suffused with this mutual interaction among the opponents' ends, ways, and means. Clausewitz's conception is not the linear, stepladder approach of the Lykke model but rather a dialectical relationship in which the desired ends determine the means required, but the means available also moderate the possible ends. The asymmetric nature of that relationship contributes to its nonlinearity.

By now, it should be clearly recognizable that even without having access to the terms in question, Clausewitz emphasizes the *deterministic* and *nonlinear* nature of war. Clausewitz tends to be criticized for his contradictions—and there indeed are many, especially within this chapter. These contradictions, however, are not just a feature of the dialectical reasoning Clausewitz uses; they are a facet of war's chaotic nature. Clausewitz's philosophical exploration into war as a phenomenon must navigate these apparent contradictions between ends and means rather than avoid them. The unity of contradictions—order and disorder, predictability and unpredictability, linearity and nonlinearity—that makes the science of complexity so fascinating, challenging, and new is nevertheless old hat to the student of Clausewitz.

Strategy and Tactics

Another aspect of war demonstrates nonlinearity: the relationship between *strategy* and *tactics*. These terms were in common use before Clausewitz's time, but his conception of them differs from both earlier and later ones, most of which relate them to scale (i.e., tactics exists at a lower level, strategy at a higher one). For Clausewitz, these two things were not a matter of levels at all but rather were "activities," each of which had its own logic. Both involve the active use of means; neither is a level on which one exists or a command level. *Tactics* is "the theory of the *use* of military forces in combat," while *strategy* is "the theory of the *use* of combats [engagements] for the purpose of the war."[32] The logic of tactics is destructive:

the defeat of an opposing force. The logic of strategy is constructive: the creation of conditions for the mutual acceptance of a peaceful political state, even if one side is coerced into that acceptance. Complexity science and chaos theory can yield insights into this need to unify discordant efforts—the achievement of peaceful ends through violent means—but linear conceptions of tactical and strategic levels (not to mention spurious conceptions of an interceding operational level) cannot.

Looking at strategy and tactics not as levels but rather as tactical actions and strategic effects helps us understand the emergent nature of strategy. Strategy is emergent from tactics. In the words of Colin Gray, "[o]ne has a strategy, which is done by tactics."[33] *Emergence*—in complexity terms—describes phenomena in which the collective activities of agents produce a higher-order behavior that is different in kind, not just in measure or degree, from the original behaviors. This is exactly what Clausewitz was trying to capture with his definitions above. Although connected, the aggregate strategic effects of tactical behavior are different in kind from the immediate effects of individual tactical engagements, and the two are put to different purposes.

Tactics and strategy therefore are not as distinct as they sound or as discrete as they usually are presented today. A military commander or military force must strive to win in combat, but also must ensure that winning in combat serves strategy. Tactics is about defeating the enemy in engagements, no matter the scale of those engagements; strategy is about using the effect of those victories to achieve the political goal of the war. A military force, even as small as a fire team, never is only "doing tactics" or only "doing strategy"; it always is doing both activities. Tactics is meaningful only if it serves the strategy, and strategy can accomplish only what tactics can deliver. The strategic effect of a single fire team probably will be minuscule, but since war is nonlinear it also might not be. Clausewitz is explicit on this point: "Strategy can therefore never take its hand from the work for a moment."[34]

More important than what the two activities are, however, is the relationship between them. Again, we must examine them holistically, not singly. While tactics delivers a victory to one side and a defeat to the other, the moral effect thereof does not "stay on the battlefield" but instead affects the course of the war. This now is called strategic effect.[35] Every tactical action produces a strategic effect, whether it is positive or negative, large or small. But the relationship between the tactical action and the strategic effect is nonlinear and unpredictable. Clausewitz explores why some battles achieve profound strategic effects and others do not, and he asserts that it is because the effect on both sides is at least as much moral as it is physical, which produces the "disproportion" (his word).[36] This moral effect of tactics, he believed, is not quantifiable, and therefore is not truly knowable. The output (strategic effect) cannot be predicted solely on the basis of identifying the input (tactical action). That Clausewitz was wrestling here with both nonlinearity and unpredictability is undeniable.

Clausewitz identified aspects of the nature of war that science—indeed, humanity as a whole—did not yet have the language or knowledge to identify. But he knew that he could not stop at identifying them; he had to synthesize them into a coherent whole. Dialectical reasoning was the best methodology he had to perform this synthesis, and he largely succeeded. It is important to note that the concepts presented in *On War,* divided by definition and character, nonetheless are inseparable. War's character exists only because of its nature, tactics exists only in relation to strategy, and means are means only in relation to ends. Again, presaging generations of scientists who have studied complexity and chaos, Clausewitz is explicit in stating this: "In this view, therefore, war is an indivisible whole, the parts of which (the subordinate results) have no value except in relation to this whole."[37] In this way, Clausewitz's framework accounts for the inherent chaos of war while also bounding it with specific parameters and describing its initial conditions that determine its unpredictable course. It is complexity theory through and through.

Offensive Warfare and Defensive Warfare

This is clear in his conception of offensive and defensive warfare as well. For Clausewitz, the difference between offensive warfare and defensive warfare is time. His assertion that defense is the "stronger" form of combat is quoted often but understood less often. The defense is the stronger form because the passing of time benefits defensive forces but detracts from the power of offensive forces. Still, neither has meaning without the other. Offensive warfare only means anything if there is an opposing force defending someone or something. Offensive and defensive warfare therefore have a "reciprocal effect."[38]

To understand why this is so, he uses the concept of *friction*. The word is borrowed from science but is redefined for warfare. Friction separates war in theory from war in practice, for once war begins any number of practical difficulties interfere with the smooth operations of military units. Confusion and unforeseen difficulties, from equipment malfunctions to communication breakdowns between units, increase the friction between commander and commanded, making even simple attacks and maneuvers difficult to carry out. This is true even before a military force has come into contact with the enemy, but once it does friction is magnified further through enemy interference.

Clausewitz devotes an entire chapter in book 1 to friction. He explicitly connects it with unpredictability: "This enormous friction, which is not concentrated, as in mechanics, at a few points, is therefore everywhere brought into contact with chance, and thus incidents take place upon which it was impossible to calculate, their chief origin being chance. As an instance of one such chance, take the weather."[39] Recall that weather itself is a chaotic system.

Friction is how Clausewitz conceptualized *entropy*—a scientific term that did not exist yet. *Entropy* is the degree of randomness or disorder that builds up within a dynamic system as it operates over time, reducing the amount of energy that can be used for its purpose. In terms of offensive warfare, the combat power of a military unit is the amount of time, attention, and energy that can be applied to fighting the opposing force. As an offensive action is carried out, unforeseen circumstances—a missing soldier, broken equipment, an unforeseen rainstorm—reduce that combat power, because the people involved have to devote energy to overcoming problems instead of carrying out the operation itself. This increases the entropy of the military force. The combat power of the offensive force also is depleted by the necessity for it to guard its flanks and lines of communication.[40]

Friction certainly occurs for the defensive force as well, increasing its entropy, but to a lesser degree than for the offense. Further, the goal of defensive warfare is easier to achieve than is that of offensive warfare. The goal of defending is to preserve—to hold ground or position to frustrate the opponent's aim; the goal of offensive warfare is to acquire that ground or position and to destroy the enemy forces that control it.[41] The latter task requires more energy than does the former. The negative nature of defensive warfare, embodied in its aim of preservation, and the positive nature of offensive warfare, in that it requires more energy to acquire an advantage over defensive forces, make this relationship nonlinear as well.

Furthermore, defensive warfare benefits from negative entropy (sometimes called *negentropy*), another modern science term that captures the essence of the idea. Negentropy is a measure of increasing order within a system.[42] As a military force embarks on offensive operations, the amount of energy it can devote to its cause begins to be depleted; literally, the energy of the people involved decreases as it is applied to the effort, and disorder begins to increase immediately. The forces that are defending, meanwhile, are gaining energy. They are resting, victualing, maintaining and fixing gear, fortifying positions, and otherwise increasing their combat power and order. The offensive force must have enough energy to carry out the operation, overcome friction, and then overcome the opponents in the combat itself, all while afflicted with entropy that increases its disorder. Meanwhile, defensive warfare increases its order and energy through negentropy. This is why Clausewitz declared defensive warfare to be the stronger form of combat. The relationship between the two is nonlinear because friction does not affect offensive warfare and defensive warfare equally; rather, the offensive forces are affected disproportionately more than the defensive forces.

Friction and Culmination

Clausewitz's concept of *friction* (his word for military entropy) plays a part in another concept: the culminating point of victory. A *culmination point,* for

Clausewitz, is one at which the combat power of a military force, offensive or defensive, is so depleted that it no longer can continue to function without resting, refitting, repairing, and reconstituting itself—in other words, the point at which entropy has overcome the system and that system must be reordered. The goal of the defense is to cause the adversary on the offense to reach this point before it accomplishes its objective. On reaching the culminating point during an attack, whether it was successful or not, the force must transition to the defense. This also can occur after a victory, when the offensive force has achieved its goal, causing the defense to culminate and retreat, but the offense no longer can pursue its beaten opponent.

Clausewitz stresses that one never can know exactly when a force, whether offense or defense, will culminate. He states that identifying the culminating point requires "a fine tact of judgment" on the part of military commanders engaged in the combat itself—an allusion again to the unpredictability and uncertainty of war as a chaotic system.[43] The interactivity of the offense and defense, as they affect each other's entropy and negentropy and make it either more or less likely that the other will reach culmination, is another aspect of chaos.

Lastly, there are degrees of culmination. If the commander of an offensive force recognizes that the defensive actions of his opponent are bogging down his force and increasing its entropy, he may react by withdrawing in good order to fight another day; the defense may withdraw in the same way. But if a commander attempts to push through the increase in entropy and the battle reaches a catastrophic point, the moral cohesion of the human beings who compose his force may be broken. Such a force likely will engage in a headlong, panicked retreat, with each man fending for himself; large, dramatic victories can be the product of this phenomenon.

It is quite simple to imagine how friction, or entropy, affects military operations. During the planning phase, a commander can make detailed arrangements, check that every subordinate unit and commander has everything in order, and make sure everyone is equipped and ready. The second the operation begins, however, the order so patiently put in place immediately starts to break down as things begin moving and the enemy reacts. As uncertainty increases, the commander no longer can know whether everyone is ready or on track. Military operations, like the universe, trend away from order toward disorder.

The Center of Gravity

The center of gravity—another concept inspired by science—is one of Clausewitz's most debated topics, yet perhaps the most important. It is elucidated most clearly in book 8, entitled "War Plans," the final book of *On War* and the most developed after book 1 (the latter being the only one he was able to revise before his death). It is necessary to examine this concept at length.[44]

Clausewitz's discussion of the center of gravity concept in book 8 comes as close as he gets to engaging in prescription vice description. The bulk of *On War* consists of a construction and description of war as a phenomenon, but the development of war plans is fundamentally about applying theory to practice. The specific chapter that describes the center of gravity, chapter 4, is entitled "Ends in War More Precisely Defined" and subtitled "Overthrow of the Enemy." Book 8 is where the focus of the work moves from what war is to how to win it.

Clausewitz introduces the *center of gravity* in this way. "All that theory can here say is as follows: That the great point is to keep the overruling relations of both parties in view. Out of them a certain center of gravity, a center of power and movement, will form itself, on which everything depends; and against this center of gravity of the enemy, the concentrated blow of all the forces must be directed."[45] In other words, the center of gravity emerges from the functioning of the system.

He does not define the concept further than this, and is willing only to describe its shape. However, he does provide historical examples of centers of gravity.

> Alexander had his center of gravity in his Army, so had Gustavus Adolphus, Charles XII, and Frederick the Great, and the career of any one of them would soon have been brought to a close by the destruction of his fighting force: in States torn by internal dissensions, this center generally lies in the capital; in small States dependent on greater ones, it lies generally in the Army of these Allies; in a confederacy, it lies in the unity of interests; in a national insurrection, in the person of the chief leader, and in public opinion; against these points the blow must be directed. If the enemy by this loses his balance, no time must be allowed for him to recover it; the blow must be persistently repeated in the same direction, or, in other words, the conqueror must always direct his blows upon the mass, but not against a fraction of the enemy. It is not by conquering one of the enemy's provinces, with little trouble and superior numbers, and preferring the more secure possession of this unimportant conquest to great results, but by seeking out constantly the heart of the hostile power, and staking everything in order to gain all, that we can effectually strike the enemy to the ground.[46]

The most important aspect of these examples is what they have in common: all are political. Even where Clausewitz cites examples of an army being the center of gravity, it is only in cases of the armies of commanders who also are the heads of their states; Alexander the Great, Gustavus Adolphus, Charles XII, and Frederick the Great all were emperors or kings as well as generals, making their armies fundamentally political as well as military. The sole example of an army as a center of gravity absent this factor is when that army is a center of gravity solely by virtue of a political connection with the smaller state in question.

A center of gravity is a locus of political power, but not just any such point. The term applies only to one of extreme importance, such as a king, a capital, an

alliance, or a charismatic insurgent who inspires public opinion against a state. It must not be "unimportant" but rather of such political importance that on it "everything depends." Therefore the *center of gravity* can be defined as an aspect of power that is politically vital to the opponent's will or ability to participate in the war. It is a point at which, if attacked, the opponent cannot ignore the attack but must react to it. Striking the point successfully either will "unbalance" or will "overthrow" the ability of the opponent to continue, leading to a cessation of hostilities or, at the least, gaining significant advantage over the opponent for the remainder of the war.

This seems too linear and predictable for Clausewitz, given that he already has established that war is chaotic, but chaotic systems also feature order within disorder. Viewing war as chaos in the colloquial sense (as random disorder), one would not expect such a phenomenon in war. But there are concepts in complexity science and chaos theory that match Clausewitz's description: *levers* or *attractors*. As mentioned previously, these are points of order within chaotic systems that, if subjected to a stimulus, will cause a change in its behavior. Recall the example of an ant colony and its nest. Any homeowner knows that defeating an ant infestation by attacking individual ants will not even produce a reaction by the colony; however, attacking the nest—its center of gravity—will.

Clausewitz stated that the center of gravity will "form itself." Order forms from disorder. The center of gravity will emerge at the nexus of politics and conflict, where the adversaries disagree on a matter of such import that both are willing to shed blood over it. We may not be able to ascertain the opponent's center of gravity or what it will take to strike it with enough force to unbalance the opponent, but we know that one will form and that we may be able to exploit it when it does. This is the nature of chaotic systems: predictability and unpredictability at once.

THE CLAUSEWITZIAN FRAMEWORK AND COMPLEX WAR THEORY

Clausewitz's theory, taken as a whole and viewed as the first attempt to grapple with the phenomenon of war as a complex system, can be termed the *Clausewitzian framework*.

John Holland, a leading scholar of complex systems, has written that complex systems "require a precise language for describing the adaptive interactions of large numbers of agents."[47] Many such frameworks have been developed for analyzing and understanding such systems, including Holland's for complex adaptive systems. For war, this precise language already exists, and largely it was Clausewitz who provided it. The grammar and logic necessary to understand these concepts in this way—of military organizations as complex and adaptive

systems and war as a chaotic system—to analyze them as such, and to contextualize the seemingly discordant order and chaos, predictability and unpredictability, and simplicity and complexity of warfare—all are present in *On War*. Clausewitz, in seeking an answer to multiple, conflicting theses and antitheses, arrived at the ultimate synthesis—almost two centuries early.

War's boundaries are set by Clausewitz's definition: *war* is an act of political interaction with the addition of other means. Once organized violence occurs between two political actors, war is occurring, and his system can be used to analyze it. Once that violence ends, the functioning of the system ends.

Boundaries are linked closely with innovation and adaptation. Clausewitz witnessed one such event in his lifetime: the shift, after the French Revolution, toward total mobilization of a society for war. Before that, the general population had been involved only tangentially in the wars of European monarchs. When this *boundary shift* occurred, beginning the age of total mobilization of a nation's resources, it enabled new strategies, particularly those of Napoléon.[48] This was a boundary shift among the population, the government, and the military that led to rapid innovation, and Clausewitz identified it as such.

The *deterministic initial conditions* of a war compose the relationship among rational, irrational, and nonrational forces of each actor, captured in the trinity. The chaotic trajectory of war is produced through that relationship as it varies over the course of the war.

The relationships between *ends* and *means, tactics* and *strategy,* and *offense* and *defense* are all nonlinear. All are subject to the friction of *entropy* and efforts to increase *negentropy*. And yet all is not lost for those who seek to use war to achieve goals; an opponent's emergent *center of gravity,* if identified and struck at, offers a measure of predictability and a route to order, and perhaps to success. Such emergent centers of gravity also hold the key to an emergent conception of *strategy:* a constant, iterative alignment of ends, ways, and means as a war develops, dependent on the nonlinear aggregation of tactical engagements. Recall that Clausewitz described a *center of gravity* as follows: "Out of them [political conditions] a certain center of gravity, a center of power and movement, *will form itself,* on which everything depends" (emphasis added). He may as well have used the word *emerges* in place of *will form itself*.

The *agents* of war are many; they include the political structures of the opponents and the military forces involved, both collective military units and the individuals engaged in combat. These agents themselves are nonlinear in aggregation and engage in self-organization, combining and recombining in an effort to achieve advantages over opposing forces. The inherent interactivity of opposing forces provides the feedback necessary for adaptation. Warfare is chaotic in the scientific as well as the colloquial sense.

Clausewitz's theory of war, viewed as a framework of complexity, establishes the Prussian as the founder of what Bousquet has described as "chaoplexic warfare." Bousquet organizes strategic thought into four paradigms of "technoscientific warfare" based on the contemporary science that informed them: mechanistic warfare, thermodynamic warfare, cybernetic warfare, and chaoplexic warfare; the last mentioned is still nascent.[49] Bousquet agrees that aspects of Clausewitz's thought presage chaoplexic warfare, but he identifies him with thermodynamic warfare, mostly because Clausewitz frequently borrowed vocabulary from the most advanced scientific concepts of his time, including friction and the center of gravity. As shown above, however, the nonlinearity and interactivity of Clausewitz's conception actually anticipated complexity rather than copied thermodynamics, notwithstanding the vocabulary used. All the major components of Clausewitz's theory have analogues in complexity; fewer can be found in thermodynamics. The dialectical relationships within Clausewitz's system and his synthesis of order and disorder anticipated complexity and chaos. The resulting school of thought might be termed *complex war studies,* and there is no telling what complex war studies, using the Clausewitzian framework as a starting point, might discover.

IMPLICATIONS FOR CONTEMPORARY ISSUES

The concepts and working of complexity and chaos theory have wide potential to assist the U.S. military with nearly every endeavor, including acquisitions, force design and structure, and command and control, among many others.[50] These are, however, outside the scope of this article, which merely seeks to establish the applicability of the field and Clausewitz's role in pioneering it. Although Clausewitz believed that theory should not follow the practitioner to the battlefield, theory serves a critical role in forming concepts that, in turn, guide doctrine, which then is executed in combat. As every military service reexamines its concepts and doctrine, theory must be the foundation, and a Clausewitzian view of war as complex must guide the shape of the foundation's structure. A number of implications follow from this imperative.

Theories based on attrition, sometimes called *denial strategies,* as the primary driver toward war termination are a fool's errand. The assumption that simply inflicting a certain number or level of casualties on the opponent will lead to capitulation must be reexamined; it will be true for some strategic actors but not others. Such ideas inherently assume a linear relationship among attrition, morale, combat power, and political will that is not reflected in reality. Moreover, quantitative examinations of casualties, such as the power laws analyzed by Richardson and others mentioned previously, have found that while there are patterns across and within wars when it comes to casualties, there is no correlation with winning

or losing. However, theories based on psychology, such as maneuver warfare, which sometimes minimize the role of attrition, also are in danger of missing the interactivity of the two. Attrition, if taken to mean the physical destruction of enemy forces and resources, plays an important role in producing psychological effects on the surviving enemy forces. The interactivity of physical action, mental effects, and moral cohesion in combat remains underexamined even in the few doctrinal publications that demonstrate an understanding of complexity, such as the USMC's *Warfighting,* MCDP 1.[51] Attrition and maneuver presented as a dichotomy to analyze violent interaction is an unsatisfactory treatment, as it focuses solely on two physical aspects of combat and places them at opposite ends of a spectrum, even though they are by no means mutually exclusive.

Equally, the interposition of an operational level of war between tactics and strategy, with tactics considered to be the building blocks of operations, which in turn become the building blocks of strategy, reflects an inherently mechanistic and linear conception of warfare that simply does not match its nature. The incorporation of this conceptualization into American doctrine in the late 1970s–early '80s should be seen as a regression in strategic theory toward an imagined, linear past. As this article has shown, the conceptualization of war as a chaotic system proves false any concept that war operates by such simplistic and additive processes. Clausewitz's conception of a dialectical relationship of interactivity and feedback between tactics and strategy captures warfare in practice more realistically. The insertion of an operational level into this dynamic is not only unnecessary but counterproductive, as it impedes a correct understanding of the relationship.[52]

A Clausewitzian reading of complexity also can shed light on a debate that has occupied the pages of this journal: that on *gray-zone operations, hybrid war,* and *fait accompli* strategies. In the Winter 2020 issue of the *Naval War College Review,* Donald Stoker and Craig Whiteside argued that the terms mentioned are a reflection of poorly considered theory and a problematic confusion of war and peace.[53] In the Summer 2020 issue, Nadia Schadlow responded, stating that these terms are indeed useful, as they "reflect the nature of today's ongoing political competitions; help to explain the mind-sets and modes of operation of our adversaries and competitors; and compel a broader group of Americans to consider their role in the competitions currently under way."[54]

In terms of complexity, adversaries engaged in these types of activities seek to operate at the "edge of chaos" in an attempt to avoid crossing over into full, unlimited war, at which point they can neither control nor predict what will happen. Both Russia's "reflexive control" concept and China's "effective control" concept are attempts to forestall the disorder and unpredictability of open warfare and to limit the ability of other actors to stop them from doing what they

will. The success of gray-zone tactics is also greatly exaggerated; Russia especially has resorted to overt armed force to achieve its objectives in Georgia and Ukraine (and is doing so again as this article is being written). Although such efforts quite clearly constitute war and not peace, as war is politics with the addition of violence *or the threat of violence,* they should be recognized and studied as what Clausewitz called *limited wars;* they seek limited objectives, and therefore they are attractive to actors such as Russia and China that seek to limit their own vulnerability. In fact, the prevalence of gray-zone operations should be seen not as a failure but as a triumph of U.S. deterrence. Both Russia and China—for now—fear unlimited war with the United States, so much so that they mostly have preferred to nibble at the edges of the international order. Far from clarifying the issue, the profligate relabeling of old phenomena with new branding obscures much more than it illuminates, inflates the danger of limited war, and contributes to a great deal of confusion surrounding the issue. Such strategies and efforts should be studied and closely examined, but they must be seen for what they are: limited wars.

Complexity theory also explains the new centrality of information warfare in modern operations. Information warfare—in the form of propaganda, signaling, and other means of communication—always has been a component of warfare. However, the ongoing information revolution has increased both its importance and its potential. Complex adaptive systems are information rich; the adaptation and interaction of components of a complex adaptive system are functions of information transmission, computation, and feedback. The U.S. military thus far has attempted to graft information-related capabilities onto existing structures and processes. There is a limit to the effectiveness of continuing to do so rather than exploring information-driven operations that plan for the pervasive nature of digital communications on the modern battlefield.

Lastly, visions of eliminating uncertainty and unpredictability from warfare are, of course, quite impossible to achieve. The elimination of the fog of war via the application of digital communications and computer systems was a common refrain of the so-called revolution in military affairs movement of the last decade of the twentieth century and the first decade of the twenty-first—and it always resided in the realm of pure fantasy. Yet the dream persists today, as the U.S. Defense Department begins to invest in maturing technologies such as artificial intelligence and machine learning in an attempt to reach the same impossible goal. Investing in these technologies indeed may, and most likely will, yield benefits in combat, but in no sense will they alter the chaotic and complex nature of war. Similarly, militaries that attempt to centralize command and control as much as possible simply are pushing against the tide; as complex adaptive systems become more sophisticated, they naturally produce increasingly autonomous agents. Attempting to impose top-down control on an inherently bottom-up, emergent

phenomenon is the route to irrelevance. Decentralized command-and-control philosophies are more apt to increase the likelihood of survival in combat.

In an introductory essay to the 1976 edition of *On War,* translated by Michael Howard and Peter Paret, Bernard Brodie compares Clausewitz's magnum opus to a work of economic theory, *The Wealth of Nations* by Adam Smith (1723–90). Brodie writes, "In most other fields the works of older writers tend to become outmoded because they are either absorbed or disproved."[55] But *On War,* like *The Wealth of Nations,* endures. Although there was no way for Brodie to know quite why, the reason both books endure is that both authors divined the inherent complex adaptive nature of their subjects. In their book on complex adaptive social systems, scientists John H. Miller and Scott Page frequently reference Smith's *The Wealth of Nations*—published in 1776—as "one of the earliest and most cohesive discussions of the topic [complexity in the social sciences]."[56] Another possible early complexity theorist was the French jurist Charles de Secondat, baron de Montesquieu (1689–1755), progenitor of the theory of checks and balances in republican government—another type of complex adaptive social system. We should not be surprised that Clausewitz was familiar with Smith and that he mentions Montesquieu by name in the preface to *On War* as an inspiration.[57] This is not to say that complexity and chaos definitely were swirling through the intellectual climate of Clausewitz's time, as that storm was still off in the distance—but Clausewitz heard the thunder.

It also is telling that the complexity science pioneer John Holland and Clausewitz both use language—itself a complex adaptive system—as an illustrative example when describing other complex adaptive systems.[58] Parallels between Clausewitz's framework and language are not implicit in *On War;* rather, they are explicit. Clausewitz specifically uses subcomponents of language (grammar and vocabulary) to communicate his system. This anticipation, by well over a century, of complexity science helps to explain why Clausewitz's work is so timeless. There has yet to be a better theory of war as a phenomenon, because no other theory has captured so much of war's complex and chaotic nature.

This is not to say that Clausewitz figured out everything; clearly he could not. Much work remains to build a theoretical edifice to house "chaoplexic warfare." The purpose of this article is merely to assert that the foundation for that structure already is set, and that Clausewitz laid the stones. But the laying of a foundation is also a call to action. Clausewitz never could have dreamed of the concepts, data, and insights generated by modern science or the vast power of the digital and computational tools available to evaluate them. Once these are leveraged properly, strategic theory is set for a revolutionary leap forward.

Yet, despite a storm of thought regarding war, chaos, and complexity in the 1990s, since then strategic theory has been overcome by its own entropy. Other

concerns—the collapse of technophilic ideas such as the revolution in military affairs and effects-based operations, the requirement to reexamine insurgency and counterinsurgency, the rise of international terrorist organizations and the necessity to study them—have dominated the field since then, along with hoary debates over whether this or that dead white man—including Clausewitz—is righter or wronger than another. The only thing certain about storms, however, is that eventually another one will arrive. Recognition of complex war studies and of Clausewitz's role as their founder at least has the virtue of making us more ready for the next hurricane.

NOTES

1. Colin S. Gray, *Strategy for Chaos: Revolutions in Military Affairs and the Evidence of History* (London: Frank Cass, 2002), p. xiv.
2. Brian Cole, "Clausewitz's Wondrous Yet Paradoxical Trinity: The Nature of War as a Complex Adaptive System," *Joint Force Quarterly,* no. 96 (1st Quarter 2020), pp. 42–49.
3. A note on translations: The Paret/Howard translation of *On War* is the most well-known and is generally considered the best, but it is more accurate to say that it is the most readable translation. Scholars such as Christopher Bassford, Youri Cormier, Jan Honig, and Christopher Coker are increasingly identifying the translation by J. J. Graham as the most accurate and faithful to the original German. Because this article relies heavily on the specific words Clausewitz used, it is based on and quotes the more accurate Graham translation. The major problem with the Graham translation—at book 7, paragraph 6b, as modified by Clausewitz's brother-in-law—does not pertain to the subject of this essay. See Olivia A. Garard, ed., *An Annotated Guide to Tactics: Carl von Clausewitz's* Theory of the Combat (Quantico, VA: Marine Corps Univ. Press, 2021), pp. 17–23.
4. Neil F. Johnson, *Simply Complexity: A Clear Guide to Complexity Theory* (Oxford, U.K.: Oneworld, 2009), p. 1.
5. John H. Holland, *Complexity: A Very Short Introduction* (Oxford, U.K.: Oxford Univ. Press, 2014), pp. 4–5. See also John H. Holland, *Emergence: From Chaos to Order* (Cambridge, MA: Basic Books, 1998).
6. Holland, *Complexity,* p. 8.
7. Ibid., p. 56.
8. Ibid., p. 25.
9. Leonard A. Smith, *Chaos: A Very Short Introduction* (Oxford, U.K.: Oxford Univ. Press, 2007), p. 9.
10. Melanie Mitchell, *Complexity: A Guided Tour* (Oxford, U.K.: Oxford Univ. Press, 2009), p. 20.
11. Ibid., p. 103.
12. James Gleick, *Chaos: Making a New Science* (New York: Viking, 1987), pp. 133–34.
13. Gray, *Strategy for Chaos,* p. 106.
14. Discussed in Johnson, *Simply Complexity,* pp. 181–85.
15. Ibid., pp. 185–87.
16. For more on complex adaptive social systems, see John H. Miller and Scott E. Page, *Complex Adaptive Systems: An Introduction to Computational Models of Social Life* (Princeton, NJ: Princeton Univ. Press, 2007).
17. For Moltke, steeped in Clausewitz's thoughts, the unpredictability in war was paramount: "No plan of action can look with any certainty beyond the first meeting with the major forces of the enemy. . . . The commander is compelled during the whole campaign to reach decisions on the basis of situations that cannot be predicted." Quoted in John A. Lynn, *Battle: A History of Combat and Culture* (Boulder, CO: Westview, 2003), p. 212.

18. M. Mitchell Waldrop, *Complexity: The Emerging Science at the Edge of Order and Chaos* (New York: Open Road, 2019), p. 12.
19. For readability, the remainder of this article will omit "or more" when discussing opposing sides, but in this context the reader always should take the word *two* to mean *two or more*.
20. Alan Beyerchen, "Clausewitz, Nonlinearity, and the Unpredictability of War," *International Security* 17, no. 3 (Winter 1992–93), pp. 59–90.
21. Marie did not just edit and compile *On War* after Clausewitz's death; throughout the decades of their marriage she engaged in the refinement and sharpening of her husband's ideas. See Vanya E. Bellinger, *Marie von Clausewitz: The Woman behind the Making of* On War (Oxford, U.K.: Oxford Univ. Press, 2016).
22. Johnson, *Simply Complexity,* p. 30.
23. Carl von Clausewitz, *On War,* trans. J. J. Graham [Col., British army] (New York: Barnes & Noble Books, 2004), p. 1.
24. Ibid., p. 662.
25. Hew Strachan, "Michael Howard and Clausewitz," *Journal of Strategic Studies* 45, no. 1 (2022), p. 149.
26. Clausewitz, *On War,* p. 19.
27. Edward J. Villacres and Christopher Bassford, "Reclaiming the Clausewitzian Trinity," *Parameters* 25, no. 1 (1995), pp. 9–19.
28. John Holland, *Hidden Order: How Adaptation Builds Complexity* (New York: Basic Books, 1996), p. 166.
29. Anders Engberg-Pedersen, *Empire of Chance: The Napoleonic Wars and the Disorder of Things* (Cambridge, MA: Harvard Univ. Press, 2015), p. 51.
30. Arthur F. Lykke Jr., "Defining Military Strategy," *Military Review* 69, no. 5 (May 1989), pp. 2–8.
31. Clausewitz, *On War,* p. 21.
32. Ibid., p. 66. Emphasis added.
33. Colin. S. Gray, *The Strategy Bridge: Theory for Practice* (Oxford, U.K.: Oxford Univ. Press, 2010), p. 20.
34. Clausewitz, *On War,* p. 127.
35. Gray, *The Strategy Bridge,* p. 167.
36. Clausewitz, *On War,* p. 227.
37. Ibid., p. 646.
38. Ibid., p. 383.
39. Ibid., p. 59.
40. Ibid., p. 580.
41. Ibid., p. 356.
42. James Gleick, *The Information: A History, a Theory, a Flood* (New York: Vintage Books, 2011), p. 280.
43. Ibid., p. 582.
44. Subsequent to the book's publication, the term *center of gravity* has been lifted from its context in *On War* and used as a term for a completely different doctrinal concept, one far more tactical in nature. The U.S. military is the most blatant thief in this regard, using the term to mean nothing more than the main effort of a military force. This article uses the term in the context of Clausewitz's framework, not the doctrinal term.
45. Clausewitz, *On War,* p. 662.
46. Ibid.
47. Holland, *Complexity,* p. 11.
48. See David A. Bell, *The First Total War: Napoleon's Europe and the Birth of Warfare as We Know It* (Boston: Mariner Books, 2008).
49. Antoine J. Bousquet, *The Scientific Way of Warfare: Order and Chaos on the Battlefields of Modernity* (New York: Oxford Univ. Press, 2010).
50. See especially Eric M. Murphy [Lt. Col., USAF], *Complex Adaptive Systems and the Development of Force Structures for the United States Air Force,* Drew Paper 18 (Maxwell Air Force Base, AL: Air Univ. Press, 2014), and Trent Hone, *Learning War: The Evolution of Fighting Doctrine in the U.S. Navy, 1898–1945* (Annapolis, MD: Naval Institute Press, 2018).
51. See Christopher Bassford, "Doctrinal Complexity: Nonlinearity in Marine Corps Doctrine," in *Maneuver Warfare Science,* ed. F. G. Hoffman and Gary Horne (Quantico, VA: U.S. Marine Corps Combat Development Command, 1998).
52. B. A. Friedman, *On Operations: Operational Art and Military Disciplines* (Annapolis, MD: Naval Institute Press, 2021).

53. Donald Stoker and Craig Whiteside, "Blurred Lines: Gray-Zone Conflict and Hybrid War—Two Failures of American Strategic Thinking," *Naval War College Review* 73, no. 1 (Winter 2020), pp. 13–48.
54. Nadia Schadlow, "It's a Gray, Gray World," *Naval War College Review* 73, no. 3 (Summer 2020), p. 139.
55. Bernard Brodie, introductory essay to Carl von Clausewitz, *On War,* trans. Michael Howard and Peter Paret (Princeton, NJ: Princeton Univ. Press, 1976), p. 52.
56. Miller and Page, *Complex Adaptive Systems,* p. 4.
57. Clausewitz cited Adam Smith in his *Bekenntnisdenkschrift (Testimonial),* a political document written to advocate for a Prussian people's war against Napoléon in 1812. See Christopher Daase and James W. Davis, eds. and trans., *Clausewitz on Small War* (Oxford, U.K.: Oxford Univ. Press, 2015), p. 206.
58. Holland, *Complexity,* p. 90.