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A Remark on the Scientific Explanation of War

Megjegyzés a háború tudományos magyarázatáról

Abstract

Knowledge and authority in war require thinking men, which follows from war's isomorphic structure, and its obvious lack of consistency and completeness. This puts an emphasis on independence of thought, the acceptance of fears and facts, prejudices, fearfulness, novelty and innovation. Only a sound method of studying war, be it scientific or not, can cement an armed force together.

Keywords: war, Clausewitz, science, authority

Absztrakt

A tudás és a tekintély megköveteli a gondolkodó embereket a háborúban, ahogy annak izomorfikus felépítése, valamint konzisztencia- és teljességhiánya is. Előtérbe kerül a gondolati szabadság, a félelmek és a tények elfogadása, az előítéletek, a rettegés, az újdonság és az innováció tudomásul vétele. Csak a háború tanulmányozásának egészséges – akár tudományos, akár nem – módszere tud egy haderőt ütőképessé tenni.

Kulcsszavak: háború, Clausewitz, tudomány, tekintély

SCIENTIFIC METHOD IN THE STUDY OF WAR

Science and scientific thinking permeates into our very life. So does the lack of it too, which can normally lead to chaos in many fields. In the case of war we speak of art rather than science and it is assumed that the truer the art of war the more effective a commander will be. Both science and art demand knowledge and a method to disseminate that knowledge for which authority is required. Whereas knowledge is based to a great extent on a scientific foundation, authority is largely unscientific. Regardless of the foundation of each component, both require thinking men. A method of studying war relies on independent research that leads to independence of thought and a consideration that war displays fears and

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facts, prejudices, fearfulness, novelty and innovation. A sound method of studying war can result in doctrines to cement an armed force together.[2] Science makes possible to establish the highest authority by a well-defined method as it stands for a set of coordinated knowledge based on facts arranged according to their respective values. In other words, science is nothing more and nothing less than organized common sense. The study of war should be classified as scientific because the method employed by which it pursues knowledge. The science of war, also called military science cannot be exact as it is concerned with the human element i.e. humans and their interactions. Human interaction in war is the result of adaptation to innumerable conditions called circumstances of which some are stable, but some are in a perpetual flux. A scientific method of examining war requires experience as all knowledge is derived from it. Reasoning and imagination root in experience as do sensation, observation, reflection, and decision. In the end this clear causal chain in which sensation / observation leads to reflection / reasoning, which again leads to decision this or that way is at the core of science. This causal chain reflects logic made up of rational thought that can either be analogical, inductive or deductive. Rational thought is analogical if we infer from particular to particular, inductive if we infer from particular to universal / general, and deductive if we infer from universal / general to particular. For military science all methods apply as we are confronted by so many facts that most causes cannot rationally be linked together with effects, and remain generally unknown.[3] Scientific method makes it possible to extract knowledge from the unknown through the application of certain laws or principles with universal inference. None of these laws / principles is more important or of greater value than the other, but it is highly recommended to consider them in harmony.[4] The very essence of causality is a series of deductive if / then statements that assume mostly linear connections in which a particular effect results from a particular cause. Clausewitz warned that in war "there is a gap between principles and actual events that cannot always be bridged by a succession of logical deductions."[5] War is composed of a complex web of interconnected constituents and circular causation in which causes and effects are connected via feedback loops. There is always a chance of escalation and we have to take into account that tiny differences between causes can lead to completely different effects. This works against generalization attempts and indicates the impossibility to predict future time paths in the form of desired effects with any certainty.[6] Approaching war in terms of causal relationships rests on the assumption that war is an analytically solvable phenomenon allowing for prediction in the form of various effects. Instead in war we more often find disguised correlations rather than detectable causal

[2] Fuller, J. F. C.: The Foundations of the Science of War. Hutchinson and Co., 1937, pp, 33–35.
[3] Ibid. 36–47; Fuller, J. F. C.: The Reformation of War. Hutchinson and Co., 1923, p. 24.
[4] Fuller: op. cit. (1923), pp, 27–28.
[5] Quotation in Clausewitz, Carl von: On War. Everyman's Library, 1993, p. 125.
[6] Stacey, Ralph D.: Strategic Management & Organisational Dynamics. Pitman Publishing, 1996, pp. 177–179.; Salmon, Wesley C.: Causation. in: Gale, Richard (ed.): Blackwell Guide to Metaphysics. Blackwell, 2002, pp. 35–42.

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chains. Consequently, there is always the risk to disregard the difference that lies between correlation of attributes and causal mechanisms.[7]

WAR'S ISOMORPHIC STRUCTURE

Causality and correlation has do with the issue of determinism / indeterminism. Both are closely related to human free will and mean that an irregularity understood heuristically is not generally incompatible with determinism, except when it has no determining conditions for its occurrence.[8] We often might not precisely know the conditions for the occurrence of many events in war, but are basically confident regarding those conditions. This confidence explains why it is possible to establish relationships between statistical properties of events, and why we are less successful in doing the same for individual events and their properties. Applying various statistical variables expresses our ability to consider the statistical properties of the elements accompanying the events. The question of whether actions and their consequences in war occur in an absolutely heuristic or deterministic fashion is not an issue that has significant importance, since real life is compatible with both alternatives. Thus the question of whether structures are heuristic or deterministic in war is basically nothing more than a subject of inconclusive controversy, since both indicate unpredictability. Heuristic and deterministic structures refer to natural forms, which stand for occurrences and phenomena we can perceive. They are isomorphic structures across the fields of human inquiry such as biological cells, economic societies, the population of organisms, and in our case war. Natural forms can be understood either as a natural complex or a natural system. Although both refer to the same, they possess different attributes. Whereas a natural complex displays purposeful forms and organic interactions among the constituents, a natural system displays chaotic forms and topographic interactions among the components.[9] Thus any given natural form can be examined either as a natural complex or as a natural system. Although both constructs stand for unpredictability, the difference comes from subjective interest. Natural complex is a form composed of constituents, which are non-separable from each other. Every attempt to divide or dissect a natural complex obviously changes its identity. Due to the organised division of labour within such a complex, one constituent's particular function complements the function of the other constituents organically. The unpredictability of a natural complex arises from non-determinism, as it reacts differently to the same stimulus. Natural system is composed of constituents that are separate, but not independent from each other, which indicates that the components act as external and arbitrary impetuses. They are separate, but have a chain-like integrity that cannot be divided. Consequently, unpredictability of a

[7] Christensen, Clayton M. / Raynor, Michael E.: Why Hard-Nosed Executives Should Care About Management Theory. *Harvard Business Review*, September 2003, pp. 67–71.
[8] Lorenz, Edward N.: The Essence of Chaos. UCL Press, 1993, pp. 157–160.
[9] Nagel, Ernest: The Structure of Science, Problems in the Logic of Scientific Explanation. Hackett Publishing Company, 1979, pp. 317–335,; Khalil, Elias L.: Natural Complex vs. Natural System. *Journal of Social and Biological Structures,* Volume 13, Number 1, 1990, pp. 11–20.

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natural system is the result of human ignorance regarding all the factors at play and we face determinism in which topographic interactions involve efficient causation.[10] War as a natural form can be regarded both as a heuristic and deterministic phenomenon in which the difference does not come as a result of the underlying attributes, but as the respective inquiry. War as a natural form indicates similarities with systems, such as the weather or rain forest. These systems might be heuristic real-world phenomena, but can nevertheless be modelled and explained to a given degree by deterministically chaotic mathematical models. The history of warfare is replete with examples in which dramatic consequences resulted from minor actions, or that identical actions, depending on the context, have resulted in different outcomes. War as a distinct and specific form of interaction does not always display a direct relationship between causes and effects. Human interactions are context dependent in which similar causes can lead to very dissimilar effects. Nevertheless, the obvious similarity between chaotic abstract mathematical models and chaotic social and cultural phenomena such as war, allow for an extended examination of unpredictability. Both depend on factors that can drive the system from stability to turbulence and back again. Prediction becomes impossible since chaotic structures are vulnerable to dissolution and the higher the number of actors and longer the time-scale of prediction, the greater the problem of accuracy. Regardless of whether events in war are seen as a deterministic or heuristic phenomena, they indicate that the general push for stability is nothing more than illusion.[11] War is full of dispersed, diffuse, intermittent and irregular processes that stand for fluid and dysphasic movements constantly eroding attempts to achieve symmetry and order. Consequently, war stands for a constant interplay between fractalisation and the drive for homogeneity.[12] War as a natural form also reminds us that any outcome reflects the complex interactions of the constituents in which unpredictability best catches the "combined effect of friction, disruption, and lethality of unit behavior".[13]

[10] Khalil: op. cit. 21–31.; Buchler, Justus: Metaphysics of Natural Complexes. Columbia University Press, 1966, pp. 1–51.

[11] Mann, Steven R.: Chaos Theory and Strategic Thought. Parameters, Autumn 1992, pp. 54–68.; Peatland, Pat A. (Lt. Col.): Center of Gravity Analysis and Chaos Theory. Air War College, Air University, April 1993, pp. 10–11.

[12] Saperstein, Alvin M.: War and Chaos. *American Scientist*, November–December 1995, pp. 548–557.; Beaumont, Roger: War, Chaos, and History. Praeger Publishers, 1994, pp. 3–12.; Nicholls, David (Maj.) / Tagarev, Todor (Maj.): What Does Chaos Theory Mean for Warfare? *Aerospace Power Journal,* Fall 1994, Internet, accessed 10. 12. 2003, available at www.airpower.maxwell.af.mil/airchronicles/ apj/apj94/nichols.html; Weeks, Michael R. (Maj.): Chaos, Complexity and Conflict. Air & Space Power Chronicles, Internet, accessed 22. 05. 2003, available at www.airpower.maxwell.af.mil/ airchronicles/cc/Weeks.html.

[13] Cramer, Friedrich: Chaos and Order, The Complex Structure of Living Systems. VCH Verlagsgesellschaft, 1993, pp. 115–117.; Pfaff, Charles A. (Maj.): Chaos, Complexity and the Battlefield. *Military Review*, July August 2000, pp. 83–86.; Herman, Mark: Entropy-Based Warfare: Modeling the Revolution in Military Affairs. *Joint Forces Quarterly,* Autumn/Winter 1998–99, pp. 85–90 (quotation p. 87).

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CONSISTENCY AND COMPLETENESS IN WAR

Regardless of how we name the aggregate results, war does not provide for consistency or completeness either. Whereas consistency refers to the lack of contradictions, completeness expresses the ability to provide for proofs of all true statements. Even if war provided for such attributes that could be described entirely in mathematical formulas, Gödel proved that even then it is not possible to reach consistency and completeness. All formal mathematical systems, despite the fact that they display completeness and consistency, are inherently incomplete. They might be true, but cannot be proved despite the abundance of existing axioms and rules of inference. Gödel understood formalisation as consistency and completeness, in which axioms and rules are tools applicable to all mathematical questions in expressible formulas. Consistency and completeness can never be reached even in formal mathematical systems, as there would always be simple problems that cannot be decided from axioms. Since problems of this kind appear in a very extensive class of formally expressible systems, he concluded that every formal system must contain propositions that cannot be decided as there would always be propositions that cannot be proved or disproved. Thus Gödel's theorem indicates that there are always propositions that assert their own improvability. Consequently, even formal systems in which the class of axioms and rules of inference can be recursively defined display undecidable propositions. Similar to a complex social phenomenon such as war formal mathematical systems are incomplete and display logical inconsistency.[14] Although his theorem refers to formal statements of mathematical truth, it also sheds light indirectly onto problems found in causal relationships during war. Among others, his incompleteness theorem explains why computer-based simulations of war are essentially unstable and display inconsistency between input and output. Computer simulations are excellent examples that even if there are definable deterministic relationships within a given system that can be formalised mathematically, we must always expect occurrences that cannot be proved or disproved in terms of causality.[15] Despite attempts to comprehend war in terms of causality we always face inconsistency and incompleteness as even simpler settings that attempt to model it, show non-linear attributes and signs of instability. The Lanchester equations were the first combat model that attempted to estimate war mathematically in terms of casualty rates. Lanchester wanted to catch the essence of loss ratios in combat based on a pair of coupled differentials. From a contemporary point of view the equations seem to be very crude and clumsy tools. Growing computing power in the second half of the 20th century has enabled analysts to model increasingly more aspects of war's complex features. However, this development has shown that the relatively simple model instability

[14] Gödel, Kurt: On Formally Undecidable Propositions of Principia Mathematica and Related Systems. Basic Books, 1962, pp. 37–41, 62, 69–72; Coveney, Peter / Highfield, Roger: Frontiers of Complexity, The Search for Order in a Chaotic World. faber and faber, 1995, pp. 25–28.

[15] Gove, Philip B. (ed. i. ch.): Webster's Third New International Dictionary of the English Language. Unabridged, Merriam-Webster Inc., 1981, pp. 153, 1635, 1819.

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of the Lanchester equation has been replaced by others, yielding more divergent and unexpected results.[16] The term structural variance was the first attempt to describe the occasional and seemingly erratic behaviour that came from a strictly deterministic mechanism of the models employed. Another attempt to describe model outputs, which were seen as irregular functions of some input parameters, resulted in the term non-monotonicity. Both terms describe erratic outputs that were regarded mostly as the analysts' faults. Although first efforts were aimed at finding reduction techniques for these anomalies, later it was found that in the case of complex simulations, even infinitely small factors such as computer rounding errors can become the source of instability. It was concluded that dynamic instability appears to be an inherent feature of complex simulations. This conclusion however, allows for a much broader generalisation. If deterministic combat models based on highly controlled conditions can display irregular outputs than real wars in which the signs of determinism are less clear may be destined to do so. Real war is always more complex than any model can ever become; therefore if relatively simple computer models can show signs of instability then "the instability of the corresponding reality is certainly implied."[17]

FROM SCIENCE TO TECHNOSCIENTIFIC REGIMES

For Clausewitz it was clear that "every age had its own kind of war, its own limiting conditions, and its own peculiar preconceptions. Each period … would have held to its own theory of war, even if the urge had always and universally existed to work things out on scientific principles. It follows that the events of every age must be judged in the light of its own peculiarities."[18] The human mind always strives for principles and causal rules in order to settle controversies and tame chaos. Clausewitz also argued that the endless complexities of war allow for considering various principles and systems only in terms of physical phenomena. Attempts to reduce war to formulas containing numbers and functions is an oversimplification that cannot not stand up against its realities. Even broad arbitrary assumptions often do not correspond with practical experience. Due to war's

[16] Sidran, Ezra D.: A Calculated Strategy: Readings directed towards the creation of a strategic artificial intelligence. Readings for Research, Spring 2004, pp. 11–13, Internet, accessed 10. 11. 2005, available at www.cs.uiowa.edu/~dsidran/ReadingsForResearch2.pdf; Speight L. R.: Lanchester's Equation And The Structure of the Operational Campaign: Between-Campaign Effects. *Military Operations Research,* Volume 7, Number 2, 2002, pp. 16–21; Glenn, James E.: Chaos Theory, The Essentials for Military Applications. *The Newport Papers,* Naval War College, October 1996, p. 75.

[17] Speight, L. R.: 'Structural Variance' or 'Non-Monotonicity' Effects in Combat Models. *A Review,* Military Operations Research, Volume 8, Number 1, 2003, pp. 18—19.; Saperstein, Alvin M.: The "Long Peace" – Result of a Bipolar Competitive World. *Journal of Conflict Resolution,* Volume 35, Number 1, March 1991, pp. 70–72.; Ilachinski, Andrew: Land Warfare and Complexity, Part I: Mathematical Background and Technical Sourcebook. Center for Naval Analyses, CIM 461, July 1996(a), pp. 125–127.; Ilachinski, Andrew: Land Warfare and Complexity, Part II: An Assessment of the Applicability of Nonlinear Dynamics and Complex Systems Theory to the Study of Land Warfare (U). Center for Naval Analyses, CRM 96–68, July 1996(b), pp. 62–64.

[18] Quotation in Clausewitz, p. 717.

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uncertainty every calculation has to be done with variable quantities. An inquiry aimed solely at physical quantities is absolutely useless since war is always intertwined with psychological forces. Human psyche does not obey rules and can only be described in vague terms. He suggested that for lack of objective knowledge soldiers should trust to their talent or luck. War as constantly changing and diverse phenomenon does not allow for laws, since it is composed of actions that have to be handled individually.[19] He warned that events in war do not turn out according to causal expectations as friction always overwhelms the participants with various disturbing and encouraging effects. Friction is such a powerful constituent of war that even surprise, which he thought as the key element of victory, could be held up by its force. He argued that war displays both human strength and weakness and due to the multitude of factors involved no causal concept can be defined with accuracy.[20] The limitation of human insight and the occurrence of unforeseeable accidents do not allow for the elaboration and selection of causal options even under favourable circumstances. War displays catastrophes, accidents and missed opportunities, which all indicate that it is more than an act of reason, and reasoning is not war's foremost activity. The means applied are not absolutely necessary or the only ones possible. War is to a great extent guesswork with numerous possibilities and wrong turns in which great results are often produced by the amplification of limited means. War has its natural inertia and friction goes together with various human failures such as inconsistency, imprecision and timidity. Friction reflects possibilities, probabilities, and luck: all indicate conditions without logical reasoning. Due to the multitude of such factors it is difficult to gauge the resistance we face, and there will always be impossible to pair the objectives and the means. Causality, exact sciences and mathematical logic are of little help since waging war is basically an art in the fullest meaning of the term. Due to this vast variety of factors, methodological examinations are rarely possible and the conclusions reached reflect more the intuitive comparison and the qualities of the individual mind. War is shaped by the character of men who take and execute decisions rather than by general and universally applicable rules.[21] Despite unpredictability, non-linearity, determinism, incompleteness and instability in war much of theorising about it reflects desperate attempts of how to organize and direct forces of various kind. The human tendency to preserve order and coherence in situations when chaos becomes unleashed, control and predictability threatens to elude to chance and contingency seems to be a persistent. Scientific methods help distinguish patterns from noise, identify regularities within randomness, uncover various laws and principles, and reveal hidden order in the midst of chaos. Scientific inquiry, which helps discovering and formulating regularities point at least in theory towards predictability and control in war. Backed by technological prowess science is seen as the means that provides certainty and the chance to order. Ordering in

[19] Ibid., pp. 153–171., 175–180.
[20] Ibid., pp. 227, 233, 304.
[21] Ibid., pp. 607–617, 623–626, 692–693, 702–708.

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the Western world, especially in the unfolding 21st century reflects techno-scientific rationality and codification, and the ability to abstract regularities and correlations. This techno-scientific regime composed of science and technology has a distinct relationship with war. It opens up new channels to speak about it together with new arrangements of power, new sets of beliefs, tools and practices since major technological advances are linked to the development of scientific knowledge. Theory, science and rationality play a key role when it comes to the scientific explanation of war.[22]

CONCLUSION

A scientific approach to war bears the danger of superficial generalisations that turn any given phenomenon into its own caricature, and logically meaningless.[23] Clausewitz warned that if an idea becomes diffuse it starts losing proper meaning and its value declines accordingly. Certain principles of war can survive ages or be rediscovered occasionally. However, the main reason for their endurance is often not due to their value or utility, but their simplicity and exceptional convenience. A scientific theory of war can serve best as a framework, and as such independent from the size and scale of the conflict, the medium that hosts it, the means by which it is fought, and likewise the amount of violence it involves. In general it is the combination of efficiency and effectiveness with the aim of finding a balance between these two attributes. It follows a mostly deductive logic whereby a conclusion about particulars, flows from a course of actions rooted in a general or universal premises.[24] Knowledge and authority in war require thinking men. So does war's isomorphic structure, and its obvious lack of consistency and completeness. This puts an emphasis on independence of thought, the acceptance of fears and facts, prejudices, fearfulness, novelty and innovation. Only a sound method of studying war, be it scientific or not, can cement an armed force together.

[22] Bousquet, Antoine J.: The Scientific Way of Warfare, Order and Chaos on the Battlefields of Modernity. New York, 2009, pp. 9–17.
[23] Galula, David: Counterinsurgency, Theory and Practice. Praeger Security International, 2006, pp. xi-xiii.
[24] Clausewitz, op. cit. pp. 554., 624.; Brodie, Bernard: Strategy as a Science. World Politics, Volume 1, Number 4, 1949, pp. 471–475.; Creveld, Martin van: The Transformation of War. The Free Press, 1991, pp. 157., 218.; Robbins, Stephen P.: Organization Theory: Structure, Design, and Applications. Prentice-Hall International Editions, 1987, pp. 25–49.; Hooker, R. D. Jr.: Beyond Vom Kriege: The Character and Conduct of Modern War. *Parameters*, Summer 2005, p. 4.

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DOI: 10.32563/hsz.2019.1.ksz.10

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BIBLIOGRAPHY

1. Beaumont, Roger: War, Chaos, and History. Praeger Publishers, 1994.
2. Bousquet, Antoine J.: The Scientific Way of Warfare, Order and Chaos on the Battlefields of Modernity. New York, 2009. DOI: 10.1080/19331680903255684
3. Brodie, Bernard: Strategy as a Science, World Politics. Volume 1, Number 4 (1949), pp. 467–488. DOI: 10.2307/2008833
4. Buchler, Justus: Metaphysics of Natural Complexes. Columbia University Press, 1966.
5. Christensen, Clayton M. / Raynor, Michael E.: Why Hard-Nosed Executives Should Care About Management Theory. *Harvard Business Review*, September 2003, pp. 67–74.
6. Clausewitz, Carl von: On War. Everyman's Library, 1993.
7. Coveney, Peter/Highfield, Roger: Frontiers of Complexity, The Search for Order in a Chaotic World. faber and faber, 1995. DOI: 10.1063/1.2807588
8. Cramer, Friedrich: Chaos and Order, The Complex Structure of Living Systems. VCH Verlagsgesellschaft, 1993.
9. Creveld, Martin van: The Transformation of War. The Free Press, 1991.
10. Fuller, J. F. C.: The Foundations of the Science of War. Hutchinson and Co., 1937.
11. Fuller, J. F. C.: The Reformation of War. Hutchinson and Co., 1923.
12. Galula, David: Counterinsurgency, Theory and Practice. Praeger Security International, 2006.
13. Glenn, James E.: Chaos Theory, The Essentials for Military Applications. The Newport Papers, Naval War College, October 1996.
14. Gödel, Kurt: On Formally Undecidable Propositions of Principia Mathematica and Related Systems. Basic Books, 1962.
15. Gove, Philip B. (ed. i. ch.): Webster's Third New International Dictionary of the English Language, Unabridged. Merriam-Webster Inc., 1981.
16. Herman, Mark: Entropy-Based Warfare: Modeling the Revolution in Military Affairs. *Joint Forces Quarterly,* Autumn/Winter 1998-99, pp. 85–90.
17. Hooker, R. D. Jr.: Beyond Vom Kriege: The Character and Conduct of Modern War. *Parameters,* Summer 2005, pp. 4–17.
18. Ilachinski, Andrew: Land Warfare and Complexity, Part I: Mathematical Background and Technical Sourcebook. Center for Naval Analyses, CIM 461, July 1996(a).
19. Ilachinski, Andrew: Land Warfare and Complexity, Part II: An Assessment of the Applicability of Nonlinear Dynamics and Complex Systems Theory to the Study of Land Warfare (U). Center for Naval Analyses, CRM 96-68, July 1996(b).
20. Khalil, Elias L.: Natural Complex vs. Natural System. *Journal of Social and Biological Structures,* Volume 13, Number 1, 1990, pp. 11–31. DOI: 10.1016/0140-1750(90)90031-Z
21. Lorenz, Edward N.: The Essence of Chaos. UCL Press, 1993. DOI: 10.4324/9780203214589
22. Mann, Steven R.: Chaos Theory and Strategic Thought. *Parameters,* Autumn 1992, pp. 54–68.
23. Nagel, Ernest: The Structure of Science, Problems in the Logic of Scientific Explanation. Hackett Publishing Company, 1979.

DOI: 10.32563/hsz.2019.1.ksz.10

2019. XII. évf. Különszám

24. Nicholls, David (Maj.)/Tagarev, Todor (Maj.): What Does Chaos Theory Mean for Warfare? *Aerospace Power Journal,* Fall 1994, Internet, accessed 10. 12. 2013, available at www.airpower.maxwell.af.mil/airchronicles/apj/apj94/nichols.html.
25. Peatland, Pat A. (Lt. Col.): Center of Gravity Analysis and Chaos Theory. Air War College, Air University, April 1993.
26. Pfaff, Charles A. (Maj.): Chaos, Complexity and the Battlefield. *Military Review,* July August 2000, pp. 83–86.
27. Robbins, Stephen P.: *Organization Theory: Structure, Design, and Applications,* Prentice-Hall International Editions, 1987.
28. Salmon, Wesley C.: Causation. In: Gale, Richard (ed.): Blackwell Guide to Metaphysics. Blackwell, 2002, pp. 35–42. DOI: 10.1002/9780470998984.ch2
29. Saperstein, Alvin M.: The "Long Peace" – Result of a Bipolar Competitive World. *Journal of Conflict Resolution,* Volume 35, Number 1, March 1991, pp. 68–79. DOI: 10.1177/0022002791035001004
30. Saperstein, Alvin M.: War and Chaos. *American Scientist*, November-December 1995, pp. 548–557.
31. Sidran, Ezra D.: A Calculated Strategy: Readings directed towards the creation of a strategic artificial intelligence. Readings for Research, Spring 2004, pp. 11–13, Internet, accessed 10. 11. 2005, available at www.cs.uiowa.edu/~dsidran/ReadingsForResearch2.pdf.
32. Speight L. R.: Lanchester's Equation And The Structure of the Operational Campaign: Between-Campaign Effects. *Military Operations Research,* Volume 7, Number 2 (2002), pp. 15–33.
33. Speight, L. R.: 'Structural Variance' or 'Non-Monotonicity' Effects in Combat Models. *A Review,* Military Operations Research, Volume 8, Number 1, 2003, pp. 17–33.
34. Stacey, Ralph D.: Strategic Management & Organisational Dynamics. Pitman Publishing, 1996.
35. Weeks, Michael R. (Maj.): Chaos, Complexity and Conflict. Air & Space Power Chronicles, Internet, accessed 22. 05. 2003, available at www.airpower.maxwell.af.mil/airchronicles/cc/Weeks.html.