From sandboxes to laboratories: evolution of wargaming into a method for experimental studies

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Abstract- The following article is an attempt at conceptualization of using wargaming as a proxy laboratory. This paper investigates the potential of wargaming as an experimental study by presenting the review of scientific wargaming and its predecessors from the discipline. Based on the literature review, multiple categories of wargames can be recognized with its own perspective on common parameters in specific scenarios. The review led to a preliminary taxonomy which can be derived from the categories paired with parametrization.

Four main parameters of the wargames are compared: the players (actors present in the conflict), the units (military), board (area of competition) and victory (conditions of winning). The parameters are listed alongside the scientific and professional wargames, providing a sample of state-of-the-art in the discipline. The comparison of wargames is paired with the identification of research gap, which leads to statement of essential research questions to be considered as attainable with the experimental studies.

The question on a structured method of designing the experiments remains opened due to high variability of chosen factors. Conclusions present the concept of applying the experimental study to the framework of wargaming. This concept can be applied further to deepen the understanding of research questions which require systemized trials. This article offers a point of reference which can be leveraged in future investigations by using the key common parameters alongside features of the experimental studies.

I. Introduction

2019 Nobel Prize in Economic Sciences has been awarded for the use of experimental approach to alleviating poverty[i] by dissecting the complex system into specific, measurable set of research questions with accompanying real-life trials. Instead of projecting assumptions about possible solutions, the researchers have tested competing protocols towards improvement of the baseline (for example rate of vaccinations in Indian villages in intervention based on different incentives[ii]).

Using experimental studies to structure the framework of wargaming leverages the same approach to investigate range of outcomes in specific scenarios. Due to the hazardous nature of topics approached with wargaming, the methodology based on proxy laboratory is highly applicable. The main questions which wargaming is trying to answer have been evolving over time and the systematic review can provide a direction towards parameters and examples of previous use of specific protocol.

II. Methodology

Experimental study can investigate ways to identify commonly accepted assumptions and assess their validity. Within the discipline of wargaming, real-life experiments could raise understandable objections. In absence of in vivo trials, proxy studies have been established, as simulations or wargames. The following article provides a review of the concept of using experimental studies to address uncertainties. Wargaming addresses uncertainty by role-playing essential interdependencies, including different aspects of the conflict[iii]. The changes of parameters can be registered and examined, and at a later stage dissected into individual research questions.

The following section provides a sample of existing approaches to wargaming and the ways which they approached specific scenarios. It builds on the common parameters present in all cases, recognizing how the design of the system influences the experiment. The initial comparison investigates the players represented in the wargames, board delineating the area of competition, units which can be operated by the players and the winning conditions established as a determinant of success. This overview presents the table-top wargames.

A wargame is often referred to as a combination of ‘game’, history and science[iv]. This combination is reflected in several disciplines which used wargaming as a methodology and the wide range of topics which it helped study. It is quite difficult to establish the basic assumptions of a still evolving discipline. This section will provide an insight into the origins of wargaming and the models prevalent in the practice. Within this review, it is clear that several authors have already pointed out knowledge gaps and need for alternative approaches.

III. Literature review

The literature review is conducted based on Webster and Watson[v] recommendations on capturing the relevant sources which shed light on the state of the art in the discipline and shows the gap which can be contributed to. Within the main databases of scientific publications, in the search conducted in May 2019, the results for the term ‘wargaming’ would yield respectively: 136 in Web of Science, 166 in SCOPUS and 202 in JSTOR. This reflects the two facts about wargaming discipline: it is relatively new and it remains largely undisclosed - much of the resources belong to governmental and commercial classified archives.

In the published articles, main clusters formed around technical application of wargaming rather than the concept which it followed. The categories in which the articles were grouped

were related mostly to: Computer Science Interdisciplinary Applications, Computer Science Theory Methods, Operations Research Management Science, Political Science, Engineering Electrical and Interdisciplinary, Management, History and Optics. The broad catalogue of disciplines employing the method shows that the approach is studied outside of the military sphere and applied as part of the analytical frameworks. It is often employed as complementary to other elements:

Wargames are synthetic experiences; to make the most of them, we need to integrate them with all the other tools (analysis, exercises, history, real-world experience) that we have available to help us make sense of what we can and should focus on in the present and the future[vi].

Such broad use of wargaming in multiple ways and within different disciplines and alongside other tools multiplied the ambiguities of the methodology, creating several versions of wargaming. This in turn produced many varying examples of making wargames, not as controlled instruments, but as a way of understanding a particular phenomenon. This rich practice base and a narrow codification point requires a separate description in order to view the existing system of wargaming.

IV. Reviewing Literature, Practice and History

Wargame in its academic purpose, has been defined as a model or simulation of war conducted without maneuvering actual forces and with a sequence of events that affects and is affected by decisions of the players[vii]. The decision-makers draw from their experience and can relate the problems at hand to a form of reality. Starting from the beginning is challenging in the area of wargaming, as it can be traced to ancient times and all civilizations in its organized form. The oldest formal game has been found in the Royal Tombs at Ur dating back to 3000 BC[viii]. The first of the recorded wargames was authored by Sun Tzu, called "Wei Hai" - encirclement, dated around IV century BC[ix]. At the time, wargames were seen as the instrument of training royals and commanders in the art of war.

The most encompassing overview of history of wargames has been provided by Martin van Creveld in *Wargames: From Gladiators to Gigabytes*[x], where the author presented the games as following the structures and development of human groups (for example hunters, villagers, warriors – all playing to learn the skills required to survive).

The learning and knowledge building worked not only inside the social groups, but also outside - as games influenced popular culture. Examples of this can be found in the Ancient and Medieval Wargaming producing symbolic depictions like *Spartacus* and more entertaining games like *Field of Glory: Ancient and Medieval Wargaming*[xi] and *Lost Battles: Reconstructing the Great Clashes of the Ancient World*[xii].

Historical examples of wargaming will be viewed through two perspectives: what time period they represent[xiii] and how they address the four focus variables: Players (P), Units (U), Board (B), and Winning (W). Main differences in wargaming based on historical criteria could be summed up in the categories below[xiv] (the period and topic can classify a wargame into more than one category at the same time):

1. Ancient Wargaming (3000 BC to 1500 AD) – representing the wars in Ancient Age reflects the most renowned conflicts of the time: Rome and Greece, Persians, Carthaginians, Huns, Celts, and numerous battles in Europe[xv]. The clashes show amassed maritime clashes, mountain warfare, militarized cities such as Sparta, mercenaries as in Italian kingdoms, religious wars and imperial models of governance.
P: Alexander the Great, Hannibal, Julius Cesar; Egyptian, Nubian, Asiatic, Libyan, Hittite, Sea Peoples, Assyrian, Aramean (Syrian), Hebrew, Urartian, Median, Elamite, Babylonian, Scythian;
U: Hoplites, Roman legion, horse rangers, phalanxes and cavalry;
B: Greece, Rome, Byzantium, Middle East;
W: military victory - destroying enemy's army or capital city.

2. "Dark Age" Wargaming (600 AD – 1000 AD) – defined by the fall of the Western Roman Empire, represents the confrontation of barbarian tribes and civilization and a growing number of revolts, such as Jacobite in Britain[xvi]. The tactical challenge includes countering quality with quantity, mobility and fortresses.
P: William the Conqueror, Vikings, Saxons, Germanic tribes, Romans, Arthur, Boudica, Aurelian, Huns, Magyars
U: shield walls, warbands (bands of infantry), cavalry, light troops, archers, swordsmen, spearman, axeman, crossbowman, war dogs,
B: Hastings, Macedonia, Europe, Byzantine Empire, Ireland
W: military victory - destroying enemy's army or capital city; uprising victory - defending territory against ruling (usually stronger) army;

3. Medieval Wargaming (1100 – 1400) – Representing the monarchy/class system and chivalry that arose as elite units. The role of knights and tournaments was a peak of tactical duel. By the end of the period, also farmers were assigned as fighting force. Although not limited by time in history, siege of royal cities constitutes a substantial part of Medieval Wargaming.
P: Saladin, Persia, Crusaders, Muslims, Kings, Joan of Arc;
U: knights, cannons, (english) longbow, horse archers, mercenaries;
B: Europe, Mediterranean, Wisby, Constantinople, Africa, Grunwald, Orleans;
W: military victory - destroying enemy's army or capital city; decapitation victory - defeating the king (usually in battle); siege victory - breaking through fortified defences of a city;

4. Renaissance Wargaming (1450 – 1650) – Also referred to as the Pike and Shot[xvii] period, after the main weapons of the time. A comprehensive rule book for the renaissance wargaming has been compiled by Phil Barker and can be consulted for a detailed description of specific armies[xviii]. The development of gunpowder and cannon has broken through the dominance of castle fortification and undermined the elite role of noble man and cavalry in battles. Tactical units include the cannons and early type rifleman.
P: Ottomans, Genoese, Venetians, Byzantine, Italy, China, Japan, Aztec, Christian, Protestant, Russia
U: cannons, riflemen, cavalry, pikes, dragoons, war wagons, ships
B: Crecy, Poitiers, Agincourt, Mediterranean, Varna, Italy, Europe, Africa, Americas

W: military victory - destroying enemy's army or capital city; colonial victory - taking over rule of distant territories;

5. Horse and Musketeer Wargaming (1700-1860) – mostly marked by employment of regular armies and increased range of cannons. The period has mixed the cavalry of old type with new musketeers, starting a competition between maneuver and firepower.
P: France (especially Napoleon), Russia, Austria, Britain, Duchy of Warsaw, Dutch and Belgian, Germany and Prussia, Ottoman, Spain, Italy, Sweden, American (USA), Canada;
U: jager, musketeer, cannon, cavalry, hussars, artillery, general;
B: Waterloo, Warsaw, Nassau, Cartagena, Trafalgar;
W: military victory - destroying enemy's army or capital city; colonial victory - taking over rule of distant territories;

6. Rifle and Sabre Wargaming (1860-1900) – industrialization and developments of the rifled weapons have led to marginalization of previously potent cavalry. The American Civil War is one of the predominant topics in this period, testing the battlefield tactics alongside societal issues like representation, North-South division and slavery.
P: Britain, Ottomans, America, Spain, Italy, Zulu, China;
U: sharpshooters, artillery, fileman, ships, infantry;
B: Sedan, Balaklava, American Civil War battles, Africa, South America, Panama;
W: military victory - destroying enemy's army or capital city; colonial victory - taking over rule of distant territories; independence victory - taking over rule of own territory (usually by native population);

7. Industrial period Wargaming (1900-1945) – both the scale and advancement of weapons have reached its peak. Most of the topical games include World War I and World War II within different fronts. The wargames conducted in the US and UK are often cited as innovative, as they have improved the tactics of convoys against submarines in real-life operations. The US Naval War College is marked as one of the most active centers, conducting 136 wargames between 1919 and 1941, mostly pitting US forces against Japan[xix].
P: US, UK, Germany, Russia, Italy, Japan;
U: Tanks, Artillery, airplanes, ships, submarines, motors, long-range missiles, intelligence units, infantry, snipers;
B: Africa, Europe, Pacific Ocean, Pearl Harbor;
W: military victory - destroying enemy's army or capital city; coalition victory - winning as a group of nations against another enemy or group of thereof;

8. Cold War Wargaming (1945-1990) – Mostly representing the challenge of two dominant blocks and their proxies fighting for influence and ideological supremacy. This period does include a broader than earlier understanding of superpowers, economical regimes, espionage. Unique for this period, the feature of "Iron Curtain" dividing Eastern and Western blocks, provides insight into divided communities.
P: Soviet Union, USA;
U: spies, tanks, long-range missiles, nuclear weapons, infantry, satellite states (for influence);
B: Europe, Cuba, World;
W: military victory - destroying enemy's army or capital city; coalition victory - winning as a group of nations against another enemy or group of thereof;

9. Nuclear Arms Wargaming (1945 -) – The employment of first nuclear bombs have shifted the range of possible solutions towards final annihilation ("burning the soil" was known since ancient times, but did not poison the territory with radiation). Later technological advances have provided the option of tactical nuclear weapons. This type of wargaming was most prominent at the peak of Cold War arms race. The renowned "escalation ladder" was developed for scenario-building in the 1960s. It is still recognized as an issue of value in relation to North Korea and Iran today. It also crossed to the popular culture within the board game: 13 Days: The Cuban Missile Crisis;
P: USA, Russia, India, Pakistan, Iran, France, UK;
U: Strategic nuclear weapons, tactical nuclear weapons;
B: Europe, America;
W: Nuclear victory - destroying the enemy and surviving its response; Deterrence victory - leading the enemy to believe that he cannot survive the first strike against and therefore keeping the peace intact;

10. Counterinsurgency Wargaming (1960 -) – This type of wargaming has come to high visibility during the Vietnam War. It recognizes the challenge of "human terrain" and losing wars even with numerical/resource superiority. As pointed out by theorists, a revolutionary war is 20% military and 80% political formula[xx]. This disparity of goals and means has led to development of a COIN (Counterinsurgency) series of wargames depicting historical (Vietnam, Korea), and current (Iraq, Afghanistan[xxi]) conflicts. Those often portray political movements and ethnic tribes alongside resources and forces in the area of competition.
P: USA, Viet Cong, Talibans;
U: guerilla, insurgents, infantry, air support, drones (since 2015);
B: Vietnam, Afghanistan, Iraq;
W: military victory - destroying enemy's army or capital city; state-building victory - achieving stability and new government leading the country (in which the war took place);
Not established in the literature yet, but existing within practice, is the last category covering a range of activities which are related to gaming of peace. The combination of wargaming and peace in the name seems like a contradiction, but the two words refer to the topic (of peace) and the method applied (by using wargame), therefore actual.

11. Peace Wargaming (1990 -) – Although escaping the traditional outlook on wargaming, Peace games provide the de-escalation exercise to the public. Essentially, it is a reversed wargame, where the goal is to bring peace to an area (it can feature military means as well). Those wargames very often focus on one of the interventions of humanitarian and/or military actor and its challenges, revealing the additional layer of population needs (next to the military goals).
P: Military, government, population, international organizations, non-governmental organizations;
U: infantry, peace-keepers (UN, NATO), air force, local people, IOs and NGOs workers;

B: conflict areas, historical and current threats depicted on board; W: comprehensive approach - majority of players reach a solution/improvement strategy;

V. Evolution not revolution

As shown by the overview above, the categories of wargaming have been evolving with the new technologies used to fight the wars as well as some winning/losing conditions. The universe of wargaming is difficult to quantify or standardize towards a method. It is, however, built on several pervasive models of competition, which have been criticized as un-fit for investigations into current conflicts. Questions which are not included in the existing wargaming studies should be prioritized to contribute to filling the research gap.

VI. Research gap

Wargaming existed since the dawn of times and the first sand tables with stones representing opposing forces. Over time, those models have evolved into multivariable analysis of the number, range and technological sophistication of the units. This numerical fidelity has increased the resolution of the models, but not the number of factors and concepts which influence the outcome. This limited view has been criticized by active personnel in the armed forces and governmental researchers:

- *Rather than always resorting to expressing simulation results in terms of kill rates and loss ratios, we should seek to paint a more comprehensive picture of the factors that make up victory or defeat. We should routinely think in terms of movement speeds, decision points, intelligence, command and control, deception, suppression, and morale. We will be aligning our simulations with battlefield realities instead of with analytically useful fiction*[xxii].
- *A key element of analytical work should be qualitative modeling, including cognitive modeling of the decision-making and behavior of commanders, political leaders, and even societies. Such modeling should be undertaken in an uncertainty-sensitive framework and can greatly enrich analysis while breaking down the barriers between "rigorous analysis" (usually quantitative, but rigid) and human gaming (often more realistic and innovative, but fuzzy)*[xxiii]

Among several recommendations for further development, the Human Dimension seems to be prevalent, considered as the source of high uncertainty in the modelling of warfare. Human factors have been identified throughout military science and often marked as "intangibles". Reluctance to develop new approaches has led to repeated mechanisms failing to address reality and perpetuated the "bottom-up" method instead of exploratory measures, showing the broad spectrum of uncertainties.

Another difficulty has been identified in the way that the results of the wargames are communicated. Specifically, the lack of understanding of plots, charts and graphs with the quantified results[xxiv]. This applies to the data generated, as well as the need to visualize the impact of decisions made by commanders[xxv], to avoid being a black box with quantitative outputs that did not readily translate to intuitive explanations or represent the qualitative data and relationships of importance[xxvi].

VII. Experimental wargaming concept

There is a limited published insight into scientific use of wargaming. This section therefore provides a break-down of using wargaming as an experimental study method. Experimental research has been formalized in several disciplines, due to two main reasons:

1) identification of variables that can be used in an experiment (as in the case of physics and psychology),
2) existence of research questions that are not answered by non-experimental methods (linked to causality in political science)[xxvii].

In case of wargaming, the variables which might be used include earlier identified number and nature of players, units, mechanics, board and winning conditions. The research questions which are suited for experimental study could be based on the change in those variables and the effects of the change for the system. The participation of humans in the decision-making process allows to answer questions which would not be suited for an automated simulation. It can also bring new questions within the exploratory wargames. These insights of the participants have to be waged against the epistemic dependence - experts dominating the overall design and not consulting with other sources[xxviii]. Within wargaming, this can be aided by comparisons to real-life cases and extending the participants base to account for the biases. Davis proposed the Model-Game-Model Paradigm, which uses human as live feedback loop resembling the theory-test-theory scientific method for problems which are empirically unfeasible to test, such as crisis, nuclear war or escalating conflict.[xxix]

With this initial concept principles, the experimental design of wargame can be proposed. Among the elements of experimental design, the following are enlisted[xxx]:

1) Time series - identifying the elapsed time period;
2) Feedback - If the time series are connected with responding stimulus, it can be described in feedback loops;
3) independent variable - variable which is introduced to measure response to its levels;
4) dependent variables - those variables that are measured as response to the independent variable introduction;

Those elements are designed with focus on answering a research question, usually with a set of trials. The full collection of trials that addresses the current research question is referred to as an experiment[xxxi].

Using wargaming as an experimental study can: falsify a model by demonstrating that humans frame issues differently than is allowed for in the model, enrich a model by noting additional factors, creatively change the character of the problem, identify "frictions" that need to be represented in a realistic model[xxxii]. This consideration alongside the identified research gap can serve as an indicator of research questions which can be chosen for investigation with this method.

VIII. Conclusions

The increasing use of experimental studies across different disciplines proves the validity of the method in many settings. The basic features, parameters and research questions suitable for the experiments have been sampled across this article. The categories of wargames can be further refined towards points of reference in future studies. This conceptualization of scientific wargaming also provides recommendations on innovative and long-lasting approaches tested throughout history.

The evolution of wargaming and its prevalence throughout human history represents a search for trial-and-error base for analysis of conflict. The concept of turning this long practice into a protocol which could be applied and validated is a necessary step towards emergence of scientific wargaming. Scientific wargaming can leverage the established features of experimental studies to structure its method and findings.

Authors

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Endnotes

[i] On 14th of October 2019 The Royal Swedish Academy of Sciences has decided to award the Sveriges Riksbank Prize in Economic Sciences in Memory of Alfred Nobel 2019 to Abhijit Banerjee, Esther Duflo and Michael Kremer.

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[xiii] As these challenges are infinite, author acknowledges that these categories represent a sample of existing and future wargames aimed at explaining differences rather than ordering the wargames.

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