

## TOWARD A BOUNDED RATIONALITY APPROACH OF CYBERWARFARE

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DOI: 10.19062/1842-9238.2019.17.1.3

**Abstract:** *Research seeks a cognitive alternative to current rationalist studies on cyberwarfare. The purpose of this study is to present the cultural and intentional boundaries in the rationality of an actor's decision in cyberwarfare as a process, as well as the ways of investigating and processing empirical data.*

**Keywords:** *foreign policy, operational code analysis, image indicators based on verbs in the context system.*

### 1. INTRODUCTION

The concept of cyberwarfare was launched in the international debate after 2000 with its political, economic, military or diplomatic implications. The concept of cyberwarfare's role is to give today a series of interpretations regarding relations between state and non-state actors involving cyber-power projection activities of a state or non-state actor. Starting from Clausewitz's [1] cyberwarfare idea, we can regard it as a cyberwar-based offensive policy that is based on a state or non-state actor (even if non-state actors are not characterized by foreign policy). In this research through critical cyber infrastructure we understand the assembly of computer-servers, computer-clients and physical antenna systems (cables, fiber optics, radio antennas) [2]. This set of computing systems and physical information transport systems can be used for destruction by a state or non-state actor against the other international actors. The concept of cyberwarfare is seen as part of the informational warfare, comprising three components: radio-electronic warfare, cyberwarfare and psychological propaganda operations [3]. In this research, we will only focus on shaping cyberwarfare specific purposes and means. Thus, the cyber critical infrastructure of a state actor has as components computer-servers, computer-clients and physical systems for the transfer of information specific to a state or non-state actor. We believe that in cyberwarfare an actor's goals are to decommission as many of the specific cybernetic critical elements of an opponent. In order to model the projection forms of power (and hence the means used in cyberwarfare) using the critical national cyber infrastructure, we consider the most appropriate in the specialized literature the typology proposed by Craig B. Greathouse [1]:

1. Action of Cyber Espionage and Cyber Crime - is the bottom line of online confrontation that combines cybercrime organized with the collection of information of any kind that is specific to state or non-state actors oriented toward target cyber critical infrastructure;

2. Action of Denial of Service - encompasses all those types of cyber attacks that determine the denial of service effect between a particular computer-server and its computer-clients in the target cloud computing infrastructure;

3. Action of Focused Cyber Attack - refers to the attack on target critical cyber infrastructure but without causing great damage and its ability to recover soon (data recovery can be done);

4. Action of Massive Cyber Assault - refers to the attack on cyber critical target infrastructure causing great damage and its inability to recover shortly (data recovery can not be achieved). *Because all of the cyberwarfare elements are taking place in the field of security studies of international relations, we will further detail the elements that help us to integrate this concept into this discipline.*

In the study of international relations there are two main areas of research. The first is the study of the international political system and the second is the foreign policy analysis. The first area of research aims to study the interactions between the most important states at one time and the outcome of their interactions. The second area of research aims to study for a particular state its foreign policy and the motivations behind this policy with the directions of its evolution in the international arena. Between the two areas of research [4] consider that there are similarities "first of all, both theories are built on the discovery or recognition of models; second, theories are causal relationships explained on empirical models. "

Explanations of the two areas of international relations research have also been developed by Kenneth Waltz [5] and Fareed Zakaria [6], which emphasizes the same traits defined by the two Chinese researchers quoted above. [4] considers that the field of research of the international political system is part of what is called the "great theory" or "general theory" specific to issues such as "the continuous appearance of the war, the constant emergence of the balance of power or the replacement hegemony ". Foreign policy analysis is a "medium-level" or "local theory" theory that focuses on explaining the motivations and the particular behaviors of states.

Thus, in the theory of the international political system there are three great schools of thought generating great theories: realism/neo-realism, neo-liberalism, constructivism [7]. Among the medium-level theories of foreign policy analysis we can mention the following schools of thought: rational or bounded rational paradigm, cyber paradigm, prospect paradigm, paradigm of the organizational model, political bureaucracy paradigm, polycentric paradigm [8].

This research aims to go beyond the purely rationalist approach based only on the analysis of capabilities that define the outcome of an interaction and are already outlined in the cyberwarfare study [9]. A bounded rationalist approach is proposed which includes, besides the analysis of capabilities and elements of cultural specificity, national intentionality and image that define the motivation of an actor and which can construct for the decider the premises that restrict the totally rational logical thinking. In this research we consider that national cultural features and state intentions are characterized by imaginative-cognitive processes that limit the rationality of a political decision-maker. Therefore, according to [10]: "Cognitive mechanisms can thus be useful for explaining foreign policy outcomes, though not necessarily for predicting them. Accepting this premise would encourage cognitively oriented FPA scholars to treat their research as well as historical sciences, such as geology and evolutionary biology, where the goal of research is to develop the process by which different mechanisms of contingent interactions produced a specific result".

*So, using imaginative-cognitive processes, we can interpret the past results and we can estimate how the decision-maker could behave through the imitation mechanism of behaviors (generated by image-based motivation) that want to replicate these behaviors that they find satisfactory and give it comfort in foreign policy and cyberwarfare.*

The motivation and bounded rationality of a state actor based on cognitive-imaginative processes has been studied by a large suite of authors in International Image Theory [11], remarkably distinguished by Martha Cottam.

Cottam proposed a typology of political actors based on the analysis of capabilities, culture and intentions that will be presented in the methodologies section.

This explains to the decision-maker whether the image of the environment in which he is acting presents opportunities or threats to the foreign policy that he wishes to adopt. The basis of Cottam's research was a questionnaire of the image that the state actor had to deal with in the environment in which he acted. In this paper we will fine-tune this questionnaire by adapting it to the cyberwarfare actions defined by Craig B. Greathouse and the results of the analysis of the operational code and the additional method of Verbs In Context System (VICS). Analysis of the Operational Code is a foreign policy research approach to which several authors have contributed [12, 13, 14]. The main merit of this method is that it is applicable to document analysis and allows the extraction of psychological profiles and the estimation of the results sought by the decision makers. The two approaches will briefly be presented in the methodology section providing a way to link the results of the analysis of the operational code to the images the decision-maker has towards the environment in which it operates. So in this way emerge both approaches of international relations theory. Outcomes of the grand theory are borrowed from operational code analysis, the middle level theory of behavior is adopted by Craig B. Greathouse typology and motivation inspired by Martha Cottam studies.

## 2. METHDOLOGY

First, we will exemplify how to use the analysis of the operational code defined by Schafer [12, 13, 14] using transitive verbs statistics (VICS). The motivation to use this kind of statistics is to quantify the number of actions and implicitly the projection of power. This is explained by the number of transitive verbs that the decider presented by the subject develops on his/her present environment by direct complement. As an example, we will analyze using the verb contextual method applied to a quote from a speech by President Jimmy Carter about the Soviet invasion of Afghanistan in December 1979.

The sentence in President Carter's speech on January 4, 1980 is as follows: „Massive Soviet military forces have invaded the small, nonaligned, sovereign nation of Afghanistan...” method is the following [12]:

➤ Subject - which refers to the subject of the sentence ("Massive Soviet military forces") which is coded by Self or Other, depending on the state to which the author refers. In this case, Self refers to the US or a state allied with it. Other to the Soviet Union or its allied states.

➤ That time category refers to the verb of the sentence "have invaded" has the connotation of a negative action encoded as a punishment.

➤ Domain can be two types of internal political system or international political system as the interaction between actors.

➤ *Target and context* are expressed by Afghanistan-targeted action in the context of the Soviet-Afghan conflict between 1979-1988.

*In our research we will relate to the context and we will consider it synonymous with the image of the external environment of the deciding actor and is the imaginative-cognitive process underlying the motivation of this deciding actor. Consequently, the context will be the analysis through the imaginative questionnaire treated with transitive verbs in context proposed in the results section.*

Returning to the analysis of the operational code, it is characterized by ten indicators, of which the first five are called *philosophical beliefs* and refer to how the political actor perceives the environment around him. The second group of five indicators is called *instrumental beliefs* and represents the behavior the actor can adopt in relation to the environment around him. The actor will be called Ego, and the environment around him will be called Alter.

The *philosophical beliefs* of the Operational Code are [12, 13, 14]: P-1. NATURE OF THE POLITICAL UNIVERSE; P-2. REALIZATION OF POLITICAL VALUES; P-3 POLITICAL FUTURE; P-4. HISTORICAL DEVELOPMENT; P-5. ROLE OF CHANCE. And the *instrumental beliefs* of political actor are [Schafer, 2006] [Malici, 2009]: I-1. APPROACH TO GOALS; I-2. PURSUIT OF GOALS; I-3. RISK ORIENTATION; I-4. TIMING OF ACTION; I-5. UTILITY OF MEANS.

In his research, Schafer [12] considers the following three indicators to define actor's behaviors in the foreign policy analysis:

- P-1. NATURE OF THE POLITICAL UNIVERSE - defines the characteristic of the political environment if it is a harmonious or conflictual one and what characterizes the behavior of the actors in that political environment. The value range is from +1 for friendly to -1 for hostile

$$P_{-1} = \frac{NVTP(Other) - NVTN(Other)}{NTVT} \quad (1)$$

*NVTP(Other)* - number of positive transitive verbs with Other subject; *NVTN(Other)* - number of negative transitive verbs with Other subject; *NTVT* - total number of transitive verbs.

- P-4. HISTORICAL DEVELOPMENT - characterize the actor's ability to control a certain development/evolution/political trajectory/projection of power in the desired direction. It gives an imaginative-cognitive measure of the application by the actor of cyberwar actions of Cyber Crime, Action of Focused Cyber Attack by Craig B. Greathouse. Value range is +1 for high policy control over low policy control

**Error! Objects cannot be created from editing field codes.** (2)

*NTVT(Self)* - total number of transitive verbs with cu Self subject; *NTVT(Other)* - total number of transitive verbs with cu Other subject.

- I-1. APPROACH TO GOALS - Expresses the choice of the roadmap for selecting a policy objective. The value range is +1 for high cooperation or -1 specific to the high conflict

$$I_{-1} = \frac{NVTP(Self) - NVTN(Self)}{NTVT} \quad (3)$$

*NVTP(Self)* - number of positive transitive verbs with Self subject; *NVTN(Self)* - number of negative transitive verbs with Self subject; *NVT* - total number of transitive verbs with Self and Other subject.

As a conclusion of the Operational Code Analysis, there are six behavioral models based on Brams' theory of motion [12, 13, 14]. These are the following according to the I-1 and P-4a statistical indicators presented in the table 1 below for the foreign policy decision-maker named in the Ego's Operational Code:

Table 1. Table 1 - Organizing behaviors according to power values

	<i>Low Power</i>	<i>Medium Power</i>	<i>High Power</i>
	<b>Error! Objects cannot be created from editing field codes.</b>	<b>Error! Objects cannot be created from editing field codes.</b>	<b>Error! Objects cannot be created from editing field codes.</b>
$I_1 < 0$	Bluff	Compel-Punish	Bully
$I_1 > 0$	Appease	Reward-Deter	Exploit

The external environment of the Ego will be called Alter. Analogous to the external environment of the foreign policy actor is defined a typology with the same behavioral patterns but which are defined by the statistical indicators P-1 and P-4a and represent the Ego's perception of the Alter.

Thus, for the six behavioral patterns Schafer [12] defined the following results-specific patterns of interaction of an actor with its international environment with the meanings: Dominate and Submit are specific to a zero-sum, Dominate for winner and Submit for loser; Settle and Deadlock values are specific to a non-zero sum game in which Settle is characteristic of mutual co-operation, and Deadlock is typical of a mutual conflict [14]. These four results are hierarchically organized according to the following six sentences proposed by Schafer [12]. Each of the six sentences is associated with one of the behaviors: Appease, Reward-Deter, Exploit, Bluff, Compel-Punish, Bully (see Table 1 - Organizing behaviors according to power values).

For the six patterns of behavior we have the first three sentences that govern the Ego's perception of cooperation with Alter. These cooperative relationships can be coalitions, alliances, social contracts, etc. They are named by Schafer "Power Politics Propositions Re: Secondary Interests" [12]. The following three sentences are: Prop 1 the behavior of the Ego called Appease with the following hierarchy of results: Settle> Deadlock> Submit> Dominate; Prop 2 the Ego behavior called Reward-Deter with the following hierarchy of results: Settle> Deadlock> Dominate> Submit; Prop 3 the behavior of the Ego called Exploit with the following hierarchy of results: Settle> Dominate> Deadlock> Submit.

Also, the Ego's perception of the conflict with Alter is given by the following three sentences called Schafer "Power Politics Propositions: Vital National Interests" [12]: Prop 4 the Behavior of the Ego called Bluff with the following hierarchy of results: Dominate> Settle> Submit> Deadlock; Prop 5 Ego's behavior called Compel-Punish with the following hierarchy of results: Dominate> Settle> Deadlock> Submit; Prop 6 the Behavior of the Ego called Bully with the following hierarchy of results: Dominate> Deadlock> Settle> Submit.

All six sentences express the choices of the deciding foreign policy actor from the most desired/favorable result that is Settle for sentences 1, 2, 3 and Dominate in sentences 4, 5, 6 to the least desired/unfavorable outcome of the four, for example, Submit for sentence 1. This choice of an actor is dictated by the appreciation it gives to the result

based on its experience expressed through its culture and intentions built over time as a consequence of this experience.

Thus, the image of the environment (Alter) in which the Ego is located is its motivation in foreign policy or cyberwarfare. *The Ego motivated will choose one of the four results for which his behavior is known.*

Alter image in terms of Martha Cottam's studies is a variable dependent on the following three independent variables: "(1) perceptions of a country's ability, culture, and intention; (2) event scripts, reflecting lessons from history that policy makers use to understand the behavior of a country or to predict its behavior; and (3) response alternatives that have been consistently considered appropriate for use vis-à-vis a country. The attributes of capability, culture, and intention could not be operationalized at those levels of abstraction and were therefore broken down into smaller components "[11]. Next, we will treat items specific to the element (1): perceptions of Alter's ability, perceptions of Alter's culture, and perceptions of Alter's intention using the image indicator proposed by the author [11]. We will attempt to treat elements (2) and (3) by analyzing the operational code in the results section. Following Martha Cottam's [15] research for Alter's image, we propose the following types of images (see table 2):

- Colonial - is that image of the Alter in which it is inferior to the Ego in terms of its capabilities and culture but benign as its intention.
- Degenerated - is that image of the Alter in which it is superior or equal to the capabilities of the Ego, but cultural is poorly motivated (Equal/Inferior) and harmful as intent.
- Enemy and Ally - is that image of the Alter in which it is the Equal of Ego from the point of view of capabilities and culture. The difference between Enemy and Ally is the date of intent. This is harmful to Enemy and good for Ally.
- Rogue - is the image of the Alter in which its capabilities and culture are inferior to the Ego. His intention is harmful to Ego.
- Imperialist and Barbarian - the image of the Alter contains higher capabilities than the Ego and has the intention of harming it. From a cultural point of view, the Imperialist is superior to the Ego and Barbarian is inferior.

Table 2. Classification of Alter's images based on its capacity, culture and intent

Alter Image	Capability	Culture	Intention	
Colonial	Inferior	Inferior	Benign	High Opportunity
Degenerate	Superior/Equal	Equal/Inferior	Harmful	Low Opportunity
Enemy	Equal	Equal	Harmful	Low Threat
Rogue	Inferior	Inferior	Harmful	
Ally	Equal	Equal	Good	
Imperialist	Superior	Superior	Harmful	High Threat
Barbarian	Superior	Inferior	Harmful	

For the seven types of images of the Alter described above, Martha Cottam believes that the image of the Colonial or Degenerate Alter gives opportunities to the Ego [15]. Also the other five images of Alter are threats to Ego [15]. Because in international relations theory capabilities and culture are important independent variables that determine the behavior of foreign policy, they determine the magnitude of the opportunity or threat according to the above table. In the table below are presented for each of six propositions proposed by Schafer with the four most wanted results types associated with the High Opportunity image, the desired result associated with the Low Opportunity image, the unlikely result associated with the Enemy/Rogue/Ally (Low Threat) image, or

the least wanted result associated with the image of the Imperialist/Barbarian Alter (High Threat). (see table 3)

Table 3. Prop-opportunity-threat

		High Opportunity	Low Opportunity	Low Threat	High Threat
Alter Image		Colonial	Degenerate	Enemy/ Rogue/Ally	Imperialist /Barbarian
Appease	Prop 1	Settle	Deadlock	Submit	Dominate
Reward-Deterrence	Prop 2	Settle	Deadlock	Dominate	Submit
Exploit	Prop 3	Settle	Dominate	Deadlock	Submit
Bluff	Prop 4	Dominate	Settle	Submit	Deadlock
Compel-Punish	Prop 5	Dominate	Settle	Deadlock	Submit
Bully	Prop 6	Dominate	Deadlock	Settle	Submit

### 3. RESULTS

We state in the methodological section that the motivation of the Ego that is directly influenced by the image of the Alter and the image is composed of (1) perceptions, (2) event scripts, (3) response alternatives. So we can conclude that the context in which the Ego executes its decisions contributes to the cognitive-imaginative process, being a constituent part of the image of the Alter. Because the variables that construct the perceptual dependent variable are those that explicitly model the image in Tables 2 and 3, we will only use perception for the analysis of operational code with transitive verbs.

The context will be considered as a qualitative variable, dependent on "response alternatives" and "event scripts".

The cognitive-imaginative process determines the Ego decision-maker to take action on cyberwarfare on the environment. The initial questioner proposed by Cottam will be modified in the subsection "response alternatives" and "event scripts" to allow the analysis of the operational code and the verbs system in the context. For the "response alternatives" variable, the spectrum of classical actions is: "includes military threat or actual force, economic incentives to economic sanctions, diplomatic protests, bilateral and multilateral negotiations, or simply doing nothing; those perceived as weaker are dealt with in a more coercive fashion "[11]. It also takes into account the actor's willingness to study "bargaining" [11]. In the case of our analysis, cyberwarfare's actions will take the form of Action of Cyber Crime, Action of Denial of Service, Action of Massive Cyber Assault. For the second variables of the "event scripts" context [11]: "Event scripts were derived from statements about lessons from history: a. Historical incident used as an analogy to explain current conflict; c. Predictions about country's behavior or the outcome of "conflicts/co-operations based on table 3. The Alter's image was investigated on the basis of the analysis of the operational code applied to Ego's documents by further processing by categories of positive and negative transitive verbs [12, 13, 14]. The new questionnaire model will be called "image indicators based on verbs in the context system".

**3.1.** The collection of positive and negative transitive verbs related to the perception of capabilities that have as subject the Ego or the Alter  $NVTP_{11}^{Capability}$ ,  $NVTN_{12}^{Capability}$ ,  $NVTP_{12}^{Capability}$ ,  $NVTN_{22}^{Capability}$  on the basis of the items of the questionnaire below from item 1 to item 3c. "The capability attribute was derived from statements about the following: 1. Military strength and capability: 1a. The country's offensive and defensive military potential; 1b. The government's control over the military; 1c. The likelihood that

the country would resort to the use of military force to achieve its goals; 1d. Whether the country's military force was superior, equal, or inferior to the Alter military force; 1e.

The country's capability of using, and willingness to use, military force. 2. Domestic policy: 2a. The country's government structure (open or closed); 2b. The government's effectiveness and efficiency in implementing policy; 2c. The organization, size, and strength of the government's opposition; 2d. The government's ability to carry out a policy, achieve a goal, or abide by an agreement; 2e. Whether the decision structure was multi-tiered or monolithic (monolithic countries are assumed to be more capable since they do not have to please their publics, interest groups, or bureaucratic interests). 3. Economic characteristics: 3a. The capacity and stability of the country's economy (industrial potential, agricultural self-sufficiency, growth rate, potential for growth and development); 3b. The interaction between the Alter's economy and the other country's economy (permeability of other economy; threat to or opportunity for the Alter); 3c. The country as recipient or provider of international aid." [11]

**3.2.** The collection of the positive and negative transitive verbs related to the cultural perception that have as subject the Ego or the Alter with  $NVTP_{11}^{Culture}$ ,  $NVTN_{12}^{Culture}$ ,  $NVTP_{12}^{Culture}$ ,  $NVTN_{22}^{Culture}$  based on the items in the questionnaire below under item 4 and item 5. "The culture attribute was derived from statements about the following: 4. Comparison of culture to Alter's culture (perception of similarity implies a positive affect with low or no threat); 5. Cultural sophistication (includes social norms, literacy, religion, standard of living, scientific and technological capabilities, racial composition, nationalism and the public mindedness of citizens)." [11]

**3.3.** Collecting the number of positive and negative transitive verbs related to intentional perception that have as subject the respective Ego respective Alter with  $NVTP_{11}^{Intention}$ ,  $NVTN_{12}^{Intention}$ ,  $NVTP_{12}^{Intention}$ ,  $NVTN_{22}^{Intention}$  based on the items in the questionnaire below from item 6 to item 10.c. "The intention attribute was derived from statements about the following: 6. Goals and motives: 6a. Leaders pursuance of their goals; 6b. Leaders' and citizens' motives; 6c. Comparability of goals with Alter goals. 7. Flexibility: 7a. Leader's willingness to bargain, change tactics, and shift policy in response to Alter initiatives; 7b. The Ego's country flexibility; 7c. The linking of flexibility with cause (nationalism, imperialism, etc.). 8. Supportiveness of Alter goals and policies. 9. Whether decision structure is multi-tiered or monolithic (those seen as multi-tiered are seen as less threatening)." [11]

**3.4.** Global determine the behavioral model of the six in all three dimensions of perception by calculating the I-1 and P-4a for a given typology of Craig B. Greathouse [1] (Action of Cyber Espionage and Cyber Crime, Action of Denial of Service, Action of Focused Cyber Attack, Action of Massive Cyber Assault).

Table 4. Chi-square test to check the three influence of the capability, culture and intent of the image

X = Capability/Culture/Intention			
	NVTP	NVTN	TOTAL
Self/Ego	$NVTP_{11}^X$	$NVTN_{12}^X$	$NVT_1^X$
Other/Alter	$NVTP_{12}^X$	$NVTN_{22}^X$	$NVT_2^X$
TOTAL	$NVTP_1^X$	$NVTN_2^X$	$NTVT^X$

The relationship between the cognitive-imaginative-motivational process and the three independent variables is verified by the hi-square test (chi-square table 4).



Then the image model of the four groups with the types of opportunities and threats based on Table 5 below determines the perceived type of capability, culture and intent of Alter as in Table 2 for a given cyberwarfare action and the given context.

Table 5. Determining the Alter's images based on the frequency of positive and negative transitive verbs

X = Capability or Culture		X = Intention	
Superior	$NVT_1^X > NVT_2^X$	Good	$NVTP_1^X > NVTN_2^X$
Equal	$NVT_1^X \cong NVT_2^X$	Benign	$NVTP_1^X \cong NVTN_2^X$
Inferior	$NVT_1^X < NVT_2^X$	Harmful	$NVTP_1^X < NVTN_2^X$

#### 4. CONCLUSIONS AND FUTURE WORKS

Research is not an exhaustive one in the field of cyberwarfare research. As a novelty, it shows how the cognitive-imaginative motivational process limits the rationality of an actor. According to the rationalist paradigm widely used in cyberwarfare research, estimates are based on quantitative assessments of utility functions specific to critical cyber infrastructure capabilities. This study presented a way in which rationality is limited by the image (related by capabilities, culture and intentions) of the external environment of the decision maker and how to evaluate his/her cognitive decision. Future research is about integrating image indicators based on verbs into the context system with quantitative methods such as game theory, agent-based modeling, and qualitative predictive methods such as Lockwood Analytical Method for Prediction.

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