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"Emergent Leadership in Network Organizations"

Topics:

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Network-Centric Experimentation and Analysis

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Emergent Leadership in Network Organizations

Abstract

Complex security endeavors require more agile organizations (Alberts & Hayes, 2007). Leading and organizing such endeavors presents new challenges. Modern military coalitions and civilian partnerships, for instance, challenge traditional notions of Command and Control (C2). New organization forms and rapidly evolving situations alter "the very logic that relates (C2) problems and solutions" (Alberts & Hayes 2003, 88-89). By studying how C2 networks emerge in specific missions, one can identify C2 design and redesign options that arise for leadership and the network—allowing one to better recognize and shape C2 in action. US Department of Defense's Experimental Laboratory for Investigating Collaboration, Information-sharing, and Trust (ELICIT) provides one platform for such study. It offers a fully-instrumented counterterrorist gaming research environment where individuals configured into different organizations jointly solve analytical tasks. This paper explores the use of ELICIT to examine leadership and emergent leadership in C2 networks. The paper highlights some of the analytical foundations based on organization and network theories and presents experimental research design options. It also discusses an initial ELICIT leadership experiment approach using military leadership measures and the United States Military Academy (USMA) setting, and develops approaches for further study.

Keywords: network, organization, information, technology, emergent, leadership, complexity, C2, counterterrorism, intelligence, national security, ELICIT, CCRP, DoD

Introduction

Complex endeavors range from military coalitions operating in unfamiliar, hostile and rapidly shifting "human terrains" to firms navigating the global economy. Leading and organizing such endeavors presents nontrivial challenges. Alberts and Hayes (2003) point out, for instance, that the complexity of situations faced by individuals and organizations has outpaced many traditional C2 planning and decision theoretic capabilities. Rules and contexts have changed. Individuals increasingly face situations distinct from their previous experience: "*Not only the situations differ and the patterns become unfamiliar, but the very logic that relates problems and solutions changes as well"* (Alberts & Hayes 2003, 88-89). Resulting mission capabilities require not only the appropriate materiel (e.g., sensors, infrastructures, combat systems) but also appropriate doctrine, organization, personnel, training, and leadership design (Alberts & Hayes 2003, 127).

How does leadership emerge? Network Centric Warfare (NCW) theory (Alberts, Garstka & Stein 1999, Garstka 2000, Moffat 2003) suggests that leadership emerges as a property of the network formed by individuals involved in shared missions. C2 becomes "no longer solely the province of charismatic leaders or chance, but the result of diverse competencies and a new understanding of the role and growth of network leadership, and how it is learned and rewarded" (Clippinger 2005). This paper aims to contribute to our

understanding of these issues by developing analytical and ELICIT-based experimental approaches to the study of leadership and emergent leadership in network organizations, with US National and Homeland Security applications.

The study draws on relevant organization, information, and network theories to explore emergent leadership issues. The approach views organizations as relationship networks that pursue missions in environments. Missions refer to the work that organizations do, and the nature and purpose of that work (e.g., Daft 2004). Environments create a context within which missions take place. Environments incorporate specific physical, technological, cultural and socio-political characteristics affecting organizational abilities and survival (Scott and Davis 2007, p. 19, pp. 124-125; Phillips et al. 2004; March and Simon 1993; March and Olsen 1998, 2004). Network organizations (Granovetter 1992; Burt 1992; Powell 1990; Podolny and Page 1998; Scott and Davis 2007 Ch. 11) use technology to do work and survive in their environments (Scott and Davis, 2007: Ch. 6). While all organizations use technology, the relationships among tasks, technology choices, network structures, and environments establish particular mission abilities that lead to specific outcomes.

The associated empirical work aims to investigate such abilities and outcomes. It involves designing and conducting experimental investigations using the ELICIT multiplayer counterterrorism intelligence game capability (Ruddy 2006). ELICIT configures subjects into different organization structures including traditional hierarchy and networked Edge organization (Alberts & Hayes 2003). Players then work together within their respective organization designs to exchange and analyze information about a potential terrorist attack and to identify attack parameters (the “who”, “what”, “where”, “when”, and “how”) toward its prevention. The initial ELICIT experiment conducted at West Point used independently developed and validated military leadership measures seeking to assess the feasibility of using ELICIT for this type of study as well as to identify possible ways to measure leader emergence in initially leaderless network organizations. The findings from the initial narrowly-scoped study demonstrated the approach feasibility and generated insights and research designs for follow-on work.

Analytical Foundations

A network is a system of relationships among parts. The parts typically constitute nodes, and their relationships or connections make edges or ties. Edge and node properties and designs influence node and network behavior. Networks can represent any organization or system (e.g., Simmel 1965, Burt 1980, 1992, 2007, Granovetter 1992, Scott and Davis 2007: 280, Newman, Barabasi and Watts 2007). Networks can also represent organizational task functions transforming node inputs into outputs or generating different information structures (e.g., Radner and Marschak, 1972: 5, Cover and Thomas 1991, Shannon 1948).

Organizations need networks not only for task performance but also for the direction, coordination, monitoring, command and control of actions. The C2 structures and technologies used in networks affect performance by enabling or restricting information

flows, knowledge sharing and resource allocation. By choosing technologies and designing networks, organizations choose the parameters that will enable and constrain them. Relationships among these choices, tasks and environments establish particular organization abilities that lead to specific developments and outcomes.

Information Age technology developments have resulted in many organization participants—particularly managers and C2 professionals—devoting increasing amounts of their time to information processing and exchange. This stimulated the study of information networks. Radner (1993), for example, represented managerial information-processing as a decision-making machine, which takes signals from the environment and transforms them into workers' actions. Recognizing that participants at all levels of an organization process information and make decisions, this model reflects modern reality where much of the workforce specializes in informational activities in support of management or C2 in military terms. This approach specifies nodes (leaders and workers) and their links (task information flows) configured in different designs. Individuals' "bounded rationality" (Simon 1976, Radner 1986, 1997) or limited capacity for information processing (Tversky & Kahneman 1994) suggests advantages of information decentralization within leadership hierarchy structures. This raises the question of how to organize the resources used in information processing. Using formal models to represent managers as information processors of bounded capacity, studies examined different information-processing structures and properties.

With the ongoing growth of cross-disciplinary research into networks (see e.g., Newman, Barabasi and Watts 2006 for a review) additional tools and approaches for understanding network organizations have been developed, along with many measures of network properties and designs (e.g., Wasserman, Scott 2001, Carley, Kossinets and Watts, etc.).

Different network designs were also recognized to have systematically different complexity characteristics and associated behavior as well as robustness properties. Networks of low structural complexity (marked by a random distribution of links across nodes) have largely uniform and redundant connectivity. As a result, they exhibit low sensitivity to isolated failures or targeted attacks. Such networks tend to collapse, however, when a critical fraction of elements fails. The electricity grid in the United States is an example of a network that can withstand many isolated disruptions, but remains vulnerable to cascading disruptions. In contrast, networks with high structural complexity (marked by exponential link density distribution) have a few highly connected nodes, or hubs. Such networks are more tolerant of random disruptions, but they are sensitive to hub failures and to targeted attacks on their hubs. For instance, airline operations tend to be resilient to many local delays and problems, but disruptions at major hub airports threaten the continuity of global operations. (Barabasi 2004 on scaled vs. scale-free networks; Carson and Doyle 2002 on robust but fragile networks).

Organization theory scholars applied similar notions to organizational networks. For instance, open systems perspectives on organizations recognize system complexity (e.g., Boulding 1956, Daft 1980) shaped by tight or loose coupling (Cyert and March 1963, Pfeffer and Salancik 1978, March and Simon 1993, Perrow 1999) and capacities for self-regulation or self-maintenance in response to environmental stimuli (Scott and Davis

2007: Ch 4). Generally, more complex and tightly coupled organization systems have greater entropy, i.e., uncertainty with potential for disorder and chaos. They may avoid breakdowns and improve performances by varying their input-output interactions with the environment, as they match their internal complexity with that of the environment (Ashby 1965, Tushman and Nadler 1978). Researchers disagree on the likely outcomes of open systems. Some emphasize the inevitability of "normal" accidents as features of complex, tightly coupled organizations (Perrow 1999, Vaughan, Sagan ref, etc), whereas others propose designing for reliability through establishing cultures of mindfulness and safety (Weick 1987, LaPorte 1982, Roberts 1990, Weick and Sutcliffe, 2006). Using statistical methods and simulated organizations, scholars have investigated work, information and knowledge network designs and processes that may improve performance outcomes (e.g., Nissen 2006, Burton and Obel 2004, Levitt et al 1994).

By further studying how specific organizations manage mission information and relationships with contexts over time, one can identify design and redesign options that arise for leadership and the network (Dunbar & Starbuck 2006). Options differ depending on one's perspective, particularly on whether one is an outside observer or inside participant (Dunbar and Ahlstrom, 1995). In studying organizations, observers and participants typically focus on different things. Observers often compare organizations on objective measures to determine how they are similar or different. Observers may then consider the implications, e.g., what implications do any differences have for an organizational investment by an outsider. In contrast, participants are often more interested in how dimensions of organizations evolve over time. They generate accounts that explain how actions and outcomes have emerged in particular contexts. Combining inside and outside perspectives on organizations offers complementary insights (Drozdova 2008). When structures and perspectives change, criteria for network structure, leadership and action change. These perspectives can contrast and lead to different outcomes and understandings. One needs both perspectives to explore emergent properties in context and how they may develop or contrast with other contexts over time.

Using ELICIT to Investigate Network Organizations & Leadership

The ELICIT research environment supports such explorations (see Ruddy 2006, Leweling & Nissen 2007, Leweling 2007, for detailed descriptions of ELICIT). The fully instrumented counterterrorist intelligence game played by the ELICIT subjects allows one to trace and measure each participants' information-exchange actions as well as the organizing activity formed by these actions over time. The activity network is represented by individual player nodes as well as information exchange (website) nodes and information entity (factoids) nodes. The information flows in the course of the game form network edges. The setting generates measurements from 'outside' perspective, including records of factoids exchange and game results over time. Insider perspective is more difficult to capture with current ELICIT implementation (without communications), but one can obtain information on individual actions (factoid manipulation) and develop research designs to shed light on insider perspectives.

Initial Research Design

ELICIT Platform & Military Leadership

Ruddy 2006, Leweling and Nissen (2007) and Leweling (2007) provide a detailed description of the ELICIT platform.

Experimental design here combines the ELICIT approach with actual military leadership measures and military subjects.

Military operations involve many tasks that need to be accomplished under the pressure of time and environment. Operational success often depends on how well individuals interact with each other and with their environment to obtain, asses, share, and act upon task-related information. ELICIT allows us to investigate these information sharing behaviors in various organization forms. Edge networks are of particular interest. Because they are initially "leaderless" by design, it is not clear from the outset who may "take charge" and how information-sharing patterns will emerge and develop. Exactly who takes charge will differ as a function of the characteristics of the individuals, the situation, environment, and network configuration (Alberts & Hayes 2003, pp. 184-185). Resulting information networks and emergent leadership behaviors may support or impede organizational agility, self-synchronization, performance and possibly survival.

Leadership from the Edge of organization implies that subordinates are able and authorized to take the initiatives that are necessary to deal with the situations they face. Should leaders who emerge to take charge be best suited to particular situations, resulting Edge organizations are expected to achieve superior performance (Alberts & Hayes 2003, 2007). However, traditional military leadership characteristics may not well match the requirements of leadership from the Edge (Vogelaar, 2007; Popper 2004).

Traditional military leadership measures may also be compared with potential other and newly developed measures. US Military Academy provides one well-fitting setting.

Military Leadership Measures

In the course of their curriculum, West Point Cadets earn Military Development Score (MDS) grades. MDS is a performance evaluation assigned to Cadets at the end of each academic semester and summer training periods. It is based on ratings by supervisors, peers, subordinates and instructors (Bartone et al. 2007, Rogers, Lilley, Wellins, Fischl, & Burke, 1982). MDS grades incorporate 12 basic leader dimensions reflecting a cadet's duty performance as a leader. These are duty motivation, military bearing, teamwork, influencing others, consideration for others, professional ethics, planning and organizing, delegating, supervising, developing subordinates, decision making, and oral and written communication (U.S. Corps of Cadets, 1995; Collins & Crandall 2006). Previous research utilized these scores (e.g., Bartone et al. 2002; 2007) and verified construct validity of their dimensions (Schwager & Evans, 1996).

MDS grades are assigned on a 4-point scale similar to the academic grading system, in which 1 = D, 2 = C, 3 = B, and 4 = A (Bartone et al., 2002, 2007). In addition, Cadets are

ranked relative to others on "Overall Leadership Performance," with five ratings possible: (1) Lower 10%, (2) Lower 25%, (3) Middle 30%, (4) Upper 25%, and (5) Upper 10% (Bartone et al. 2007, 2002; U.S. Corps of Cadets, 1995).

ELICIT Activity Measures

The ELICIT game generates activity logs that can be used to calculate various measures, including frequency of interactions between participants as well as participant interactions with the Who, What, Where, and When websites, and levels of activity measured by the number of instances of sharing information factoids, receiving them from other participants, as well as posting to or pulling from shared websites (Leweling and Nissen 2007, Rudy 2006, as well as communications with Danielle Martin of EBR, 2008). Measures of leadership internal to the game include solution accuracy assessed as the fraction of elements of the attack identified correctly.

USMA Subjects

Cadets in the first and second class year would make appropriate subjects. Cadets in their "second class" year, function as noncommissioned officers within the corps-of-cadets, typically serving in platoon sergeant or squad leader roles. They have considerable responsibility for planning and implementing a wide range of training activities for the cadet-soldiers in their units. In their "first class" year, cadets have continued responsibility as leaders, serving in officer roles from platoon leader through battalion and brigade staff and commander positions (Bartone et al. 2007).

For comparative analysis, best participants would have maximal distinction on their leadership scores. For instance, half of the players may have leadership score of 1 and the other half a score of 4 on Military Development, or choose participants from top and bottom 10% scores "Overall Leadership Performance" rating based on 12 leadership dimensions. The experiment can be done with any composition of Cadets if necessary, as long as their leadership scores are comparable using uniform criteria.

ELICIT Game Day Protocol

Sample experiment agenda:

Time	Activity
12:50-12:52	Welcome Remarks
12:52-1:57	Pre-Briefing Video
1:57-1:37	Game Trial: Edge Organization (No Talking)
1:37-1:40	Required Trial Survey
1:40-1:45	Debriefing Video and Discussion

Data Collection

Cadet participation in the initial experiment was anonymous, and no personally identifiable information was collected by the researchers. A survey was used to elicit the subjects' Military Development Scores as well as basic demographic and relevant

experience data. The survey and game records were matched through a game-name randomly assigned to each subject by ELICIT. This name then served as a unique data identifier without revealing the actual identity of the player.

Table 1 shows the military leadership score and additional data collection survey. Survey length and content here is limited to essential information and minimal desired background to accommodate a limited game timeframe. The survey procedure also involves appropriate subject privacy and confidentiality protections and required human subjects research approval steps.

Survey Question	**Input Type**
1. Enter your assigned name from the experiment.	Free text
2. Have you ever participated in this experiment before?	Select one: No, Once, Two or more times, Don't know
3. Enter your age.	Free text
4. What year are you?	Select one: Freshman, Sophomore, Junior, Senior
5. Enter your Military Development Score (MDS).	Free text
6. Enter your "Overall Leadership Performance" (OLP) score if you know it. (None is an acceptable answer.)	Free text
7. List and briefly describe your leadership assignments/projects/responsibilities at USMA if any.	Free text
8. What is your gender?	Select one: Male, Female
9. How often do you use the Internet?	Select one: Never, Infrequently, Weekly, Daily, More than 3 hours a day
10. How often do you play computer games?	Select one: Never, Infrequently, Weekly, Daily, More than 1 hour a day

Table 1: Post-Experiment Survey Questions and Data Input Types.

The ELICIT software automatically collects any ELICIT based activity data.

Identifying Emergent Leadership in ELICIT

Current ELICIT instruments measure individual activity. Aggregate activity measures are calculated and attributed to organizations (e.g. total number of individuals with correct

solutions for each organization type, Edge v. Hierarchy, to determine which type performs better). Because ELICIT currently does not permit player communications, we cannot directly observe player leadership behavior such as giving or following explicit orders within the experimental platform. This limits direct measures of organizational leadership behavior, but nonetheless allows proxy measures.

In the ELICIT game no one player receives sufficient factoids to solve the game alone. Information sharing is necessary to arrive at a correct solution. Prior research has found that sharing all factoids with all participants facilitates effective solutions (ELICIT Users Group discussion, June 2007 ICCRTS). Individuals who share can thus be seen as leading their organization toward correct solutions.

Thus, one way to measure emergent organization leadership in ELICIT is through factoid sharing behavior over time. In this context, an organization leader can be defined as one who shares most critical factoids with most individuals soonest upon receiving them. Critical factoids in this case are ones that directly contribute to solving the game. Because identifying relevant factoids requires problem solving skills and sharing them reflects "delegation" as well as pursuit of common organization goal, etc., this behavior reflects many of the 12 characteristics encompassed in leadership score measures.

Other measures may involve the accuracy and timeliness of game solution as well as certain interaction patterns.

We can then explore whether and how these behaviors differs by leadership score (high vs. low) and by organization type (Edge v. Hierarchy). The propositions suggest that networking behavior is not necessarily dependent on traditional leadership scores, and hence we would not expect significantly different patterns of factoid sharing in Edge organizations composed of individuals with all high-scores, all low-scores, or a mixed-score group. We still expect differences between Edge and Hierarchy since information sharing options are unrestricted within Edge but are restricted within Hierarchy.

We can also explore whether one can identify an emergent leader in Edge by tracing factoid sharing patterns over the time-period of the game by tracing out who initiates organization-wide factoid sharing (by sending factoid to all and/or posting all to shared websites). Followers may also be identified by whether and when other players also start posting their factoids. We can look for other kinds of leader-follower behavior patterns by focusing on how participants reciprocate or repeat behaviors. By comparing their information-sharing behaviors to their leadership scores, we can investigate the extent to which traditional leadership scores may relate to Edge organization information-sharing behavior.

Ultimately, the identification and validation of various network leadership measures require further research and experimentation.

Design Options for Follow-on ELICIT Experiments on Leadership and Emergent Leadership

Additional Experiments and Replication at USMA

Follow-on series of experiments may use the initial design for replicating, verifying and extending the initial study. The same procedures can be used with some treatment variations for comparison and contrast. Such variations may include running Hierarchy to compare to Edge data with Freshmen subjects to expand our baseline of subjects with virtually no formal USMA leadership experience, against which we can then compare upper-class subjects with more advanced experience.

Should more Cadets be available with a greater variance in their leadership experience (as measured by MDS scores and specific command assignments), it would be interesting to manipulate the formal leadership score level by position. For instance, one may want to compare a Hierarchy with high-scoring leaders in Command position versus lower-level positions, and compare both to Edge. We may then evaluate the impact of traditional leadership definitions in the Edge versus the traditional Hierarchy environment, as well as possibly detect new measures of leadership that are more specific to networked settings.

Analysis plans: Table 2 provides several distinct and complementary methodological options for analyzing the resulting data, while using the initial study as a baseline for future comparisons in a campaign of experimentation. Conducting numerous experiments in the same setting, such as the USMA, offers important research advantages such as comparison continuity and controls on the environment and background experience of participants as well as readily available and externally validated leadership scores through MDS and other USMA treatments. Table 2 offers additional network measures and behavior signature to explore (Clippinger 2005).

Network Roles	Signature Pattern	Types of Links	Performance Metrics	Social Currencies
Exemplar	star, asymmetric	inform, challenge, assert	independence, trust, reach, completion rate, reputation	expertise, reputation, trust, access
Gatekeeper	asymmetric, gateway, hub, weak links, power law	invite, offer, uninvite	transparency, independence, completion, reputation	access, information, reputation
Visionary	star, sparse asymmetric, strong ties, weak links	inform, question, challenge, assert	social capital[21], reputation, initiation, reach, trust	expertise, information, reputation
Truth-Teller	dense, sub-networks, strong ties,	question, request, inform, assess, challenge	independence, reputation, transparency, trust	reputation, trust
Fixer	strong ties, weak links, hub, power law	request, offer, question, assess, directive	completion rate reputation, reach	access, goods, services, income, reputation
Connector	symmetric, gateway, weak links, small world	inform, access, invite, offer, request	density, [22]diversity, redundancy, reach, trust	access, favors, reputation
Enforcer	strong ties, sub-network, power law	directives, compliance, request, question	completion rate reputation, transparency, trust	access, favors, reputation
Facilitator	gateway, sparse, GFN	invite, request, offer	completion rate diversity, initiation, reputation	reputation, access, favors

Table 2: Network Properties of Leadership (Clippinger 2005)

An Example Multi-Run Study Design for USMA Setting

Should multiple ELICIT runs be available, a related study design would focus on exploring emergent leadership in Edge networks as follows:

- Round 1: Edge game with all participants having high leadership scores
- Round 2: Edge game with all participants having low leadership scores
- Round 3: Edge game with mixed set of participants (e.g., half of each group)

Analysis Plan: The analysis would focus on detecting possible information-sharing behavior and network structure differences related to leadership ability as measured by traditional military USMA criteria as well as detecting Edge leadership behaviors uncorrelated to traditional leadership measures yet nonetheless representing network leadership in this new organization form (using the above described measures of sharing patterns of game-critical factoids over time).

Another variation could incorporate a comparison to:

- Round 4: A Hierarchy game with high-scoring leaders assigned to commander positions (1, 2, 6, 10 and 14 in Figure 1)
- Round 5: Hierarchy game with low-scoring leaders assigned to commander positions
- Round 6: Hierarchy game with mixed assignments to commander positions

Analysis Plan: The analysis would seek behavior patterns, correlations, and relationships of interest within Hierarchy game records and results as well as a comparison to Edge.

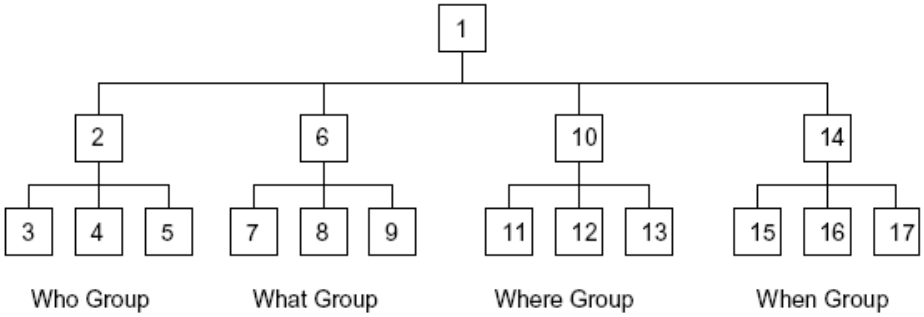

Figure 1: ELICIT Hierarchy Organization (from Leweling and Nissen, 2007)

A Multi-Run Study with Player Communications and Joint Organization Solution

To explore emergent organization behavior in depth, it would be important to focus on organizational activity—that is, beyond individual reporting that is the foundation of ELICIT today. Allowing players to communicate will stimulate organization interactions providing rich data for how situations arise and decisions are made inside particular organizations. This may limit the findings' generalizability, but offer invaluable insights into emergent behaviors and situational responses that are often critical to organization success and survival—and yet cannot be understood by traditional general hypothesis testing methods.

Should recordable player communications during the game be available (e.g., by allowing participants to use chat software to coordinate their activity), the following design can be implemented to measure emergent leadership.

Communications: Enable the players—using their (anonymously) assigned names and roles—to communicate in free text. Communications are needed for stimulating and capturing organizational dynamics while also approximating Edge organization features of greater peer-to-peer interaction, information distribution, and coordination (Alberts & Hayes 2006, also in MacEver & Martin 12-13-2006 EBR Presentation, Slide 9). Consistently with the original ELICIT setup, Edge members should be able to communicate with everybody in their organization, whereas Hierarchy members should be able to communicate only within their sub-teams (specializing in Who, What, Where or When tasks, respectively) coordinated by the commander. ELICIT software would need to record the authors, content, direction (who contacts whom) and timing of communications. This will enable the measurement of time it takes for Edge leader to emerge while also capturing the context. (Alternative implementation: web-based email

may be used, or another such capability, e.g. as implemented by the Singapore ELICIT team.)

Organization vs. Individual Solution Identification: Require each organization to report a joint solution on Who, What, Where and When of the attack, rather than having each individual player report separately. This would stimulate and reflect organization behavior and network interactions. The Hierarchy's commander will coordinate and report the solution for his team. Edge participants will need to communicate in order to finalize their solution and designate someone to report it. This will extend the previous ELICIT setup (as per Jun 2006 Parity Report) where each player reported separately, which reflected individual achievement. Here, we are interested in organizational achievement and in how the organization achieves its solution. Joint reporting will thus more closely approximate organizational behavior allowing us to observe emergent leadership. For experiment simplicity and tractability, Edge members can be instructed to vote electronically for an individual they consider their leader in achieving team solution. The majority winner would then report the solution to the moderator. (The votes may be anonymous. Other joint solution identification mechanisms can also be designed.)

The analysis may then explore the notion—derived from Edge organization theory (Alberts and Hayes 2003)—that Edge organizations self-synchronize to perform superior to Hierarchies. We can explore whether and when such phenomena may occur, and what happens during the initial time while the originally leaderless, and thus potentially disorganized, Edge organization attempts to self-synchronize and function in concert.

This kind of experiment would be conducted in two rounds—one to allow for Edge leadership to emerge, and the other to assess performance differential between Edge and Hierarchy.

Round 1: Main purpose is for Edge leader to emerge as players receive and share factoids and negotiate team solutions through communications

- Independent Variables: C2 Structure (Edge vs. Hierarchy); Communications Channel Capacity
- Dependent Variable: Leadership Emergence Rate
- Control Variables: Task Difficulty, Factoid Release Rate, and participant characteristics (as in the original ELICIT experiments), Leadership Scores

Analysis Plan: One may focus on exploring development over time and identification of emergent activity indicators. Alternatively, one may undertake simple hypothesis testing (or proposition exploration).

- Hypothesis (H1): IF it will take time for a leader to emerge THEN the organization will initially be less effective WHEN the C2 structure is established as an Edge organization.
- Measurements: time for Edge leader to emerge, solution accuracy rates, time to solution. These measures will derive from those already available in ELICIT and extended to account for joint team solutions.

- Emergent Leader Identification: Edge participants electronically submit secret ballots to the moderator, who then assigns the majority winner to serve as Edge leader in Round 2.

Round 2: Main purpose is to observe the performance differential of Edge organization with the emergent leader racing against Hierarchy to solve the attack mission (different scenario)

- Independent and Control Variables: Same as in Round 1, Leadership Scores
- Dependent Variable: Correct Solution Rate

Analysis plan:

- Hypothesis (H2) IF a leader emerges within Edge organization THEN Edge organization will be more effective WHEN led by this emergent leader in a similar mission.
- Measurements: solution accuracy rate for each team, time to solution.
- Data: This kind of experiment will generate time-stamped records of factoid manipulation (receive, post, share, etc.), free-text communication, leader votes, and solution reports. Same teams will play multiple games with different scenarios. More games would be better for generating more data. At least two games are necessary to implement the proposed two-round approach. Given the expected timeframe and resources for this experiment, the following two options are proposed—with one option to be selected depending on the subjects and venue availability:

Sub-Option 1: Half-day experiment with two games, one for each round. Consistent with the current ELICIT experiment timeframe, this estimate includes the subjects' pre-experiment briefing and training, playing the games (one hour each), post-game survey, and de-briefing.

Sub-Option 2: Full-day experiment with three-to-five games, one for Round 1 and the rest for Round 2. This option would generate more and richer data, which is preferable for analysis, but may be more difficult to implement depending on the subjects and venue availability.

Proposed analysis would focus on the following data:

- Edge member votes by name (the anonymous game name), timestamp and result as well as by Leadership Score
- Solution report actions by organization (Edge vs. Hierarchy) including timestamps, names of individuals reporting, and content.
- Solution accuracy on Who, What, Where and When parameters for each organization and each solution reported.

Analysis Plans: Time-stamped solution and vote logs will be analyzed across the mission to identify the timing needed for Edge leader to emerge (Hypothesis 1). Should the team report numerous consecutive solutions (e.g., in response to feedback), the sequence and timing of reports, the names of individuals chosen to report, and how they compare to the

leader who emerged at the end of Round 1 will be analyzed to better understand the process and timing of leader emergence. This can be done by mapping organizational activity over time and seeking patters such as correlations between factoid sharing networks and rates, solution reporting activities, and leadership scores. Focus will be on identifying activity patterns consistent with emergent leader activity.

Other Experimental Treatment Variations

The flexible approach of using ELICIT in conjunction with externally defined leadership scores as well as by identifying potential emergent leadership patters through network activity inside the game offers many opportunities for treatment variation, e.g.:

- Compare Edge versus Hierarchy as well as Edge to Edge, Hierarchy to Hierarchy, and other organization forms and combinations via experiments where participant leadership scores vary systematically. For example, one may place high-scoring leaders in Hierarchy command position versus foot-soldier position and compare their performance to each other and to Edge groups. It is quite possible, for example, that individuals who do not score highly on traditional regimented leadership measures (often developed based on traditionally hierarchical organizations and activity structures) may emerge as leaders in networked settings.
- One may also compare different military institutions (e.g., USMA versus the Naval Academy, and Air Force Academy) to each other and with subjects from foreign military organizations.
- One may also compare military and civilian leadership patterns and scores.

Such studies may generate not only useful research insights but also practical suggestions for organizing multi-dimensional inter-service collaborations, coalition organizations, and others better suited and demanded for complex endeavors.

Complementary Research Approaches

Additionally, over time as, part of an extended research campaign, it may be beneficial to complement experiments with case studies of actual Edge type organizations and example ‘complex endeavors’—current and historical. This would generate empirical insights needed to better understand what actually happens in organizations as leaders emerge and C2 networks form to deal with complex and changing situations. Findings would provide insights into what kinds of behaviors and relationships to look for and to test experimentally with statistical or computational modeling methods, what the relevant variables and measures may be, as well as appropriate assumptions and interpretations.

Conclusion

The work discussed here aims to contribute to a campaign of experimentation combined with the development of advanced research methods, concepts and useful findings. Practical goals include improving our understanding of C2 and leadership of complex endeavors and applying the findings toward improving US defense, coalition and other

national security capabilities. By understanding leadership dynamics of friendly organizations we may also be able to draw complementary insights into subversive and enemy organizations towards better addressing the various aspects of modern complex endeavors in national security and other domains.

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