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Adapting C2 to the 21st Century

Hypothesis Testing of Edge Organizations: Laboratory Experimentation using the ELICIT Multiplayer Intelligence Game

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Abstract

The *Edge* represents a fresh approach to organizational design. It appears to be particularly appropriate in the context of modern military warfare, but also raises issues regarding comparative performance of the Edge to alternate organizational designs, including more traditional hierarchal configurations. These issues suggest that laboratory experimentation, with coherently structured controls and manipulations and an appropriate data collection strategy, can offer significant insight about the internal workings of the Edge organization with high levels of reliability and internal validity. Building upon prior command and control (C2) research, we seek to understand the comparative performance of the Edge and other organizational forms, across various mission-environmental contexts, network architectures, professional competency distributions, and other conditions likely to have contingent impacts upon the relative fit and hence performance of such forms. In this paper, we report our extension of our campaign of computational experimentation to series of laboratory experiments using the ELICIT multiplayer intelligence game. ELICIT requires a team of "intelligence analysts" to collaborate—in a network-centric, information-processing environment—via information sharing pertinent to a fictitious and stylized terrorist plot. The results of our prior computational experiments are exploited to suggest in part a candidate set of research hypotheses for testing; to identify a candidate set of dependent variables for measurement; and to establish an empirical basis for further validation and calibration of our computational models in this, intelligence-focused, C2 environment. Thus this paper also proposes and instantiates how computational and empirical investigations into organizational forms can both inform and build upon the other, revealing a novel, powerful approach to C2 research. Results should enable us to isolate some particularly powerful influences over and determinants of C2 efficacy—across organizational forms and contingency conditions—and to buttress the already solid foundation of external validation that supports our computational tools. Results should also help to illustrate the power of the ELICIT game to support compelling C2 research, and to contribute important, new knowledge in terms of both organization theory and C2 practice.

INTRODUCTION

The *Edge* [1] represents a fresh approach to organizational design, which appears to be particularly appropriate in the context of modern military warfare, especially given emphasis on expanded mission sets, such as natural disaster relief [2,3], pandemic response [4,5] and stabilization operations (see e.g., [6,7]). The Edge proposes to capitalize upon fully connected, geographically distributed, organizational participants by moving knowledge and power to the edges of organizations. These changes in information accessibility and organizational transparency, coupled with distributed decision rights and empowering what would traditionally be considered lower-level organizational members, highlight promising opportunities for enterprise efficacy. However, the Edge organization also raises issues in terms of comparative performance with respect to alternate organizational designs. Such comparisons are of particular interest in military and governmental contexts given continued prominence of the paradigmatic, perhaps tautological, concept of "unity of command," [8,9] despite recognition that multinational coalition [10], interagency [11] and interorganizational networks (e.g., [12,13]) are a common situational context for defense officials and military personnel, particularly within the more senior ranks.

Further, mounting anecdotal evidence suggests that a wide variety of US military organizations—Joint and Service—are testing new organizational forms, administrative controls, responsibilities and role assignments of senior officials, and communication protocols, albeit without the benefit of controls and manipulations inherent in more rigorous laboratory experimentation [14]. US Strategic Command (STRATCOM), for example, has implemented a variant of the traditional continental staff structure typically found in the Strategic Apex [15] of combatant command staffs, and the general and flag officers serving as STRATCOM's functional component commanders also responsible for Service and interagency functions [16, 17]. Other examples of US military organizations pursuing new organizational forms (e.g., STRATCOM, see [16, 17]; Standing Joint Force Headquarters, see [18]) and interorganizational partners and coordination mechanisms (e.g., Northern Command, see [12,13]) abound.

Modern military organizations have adapted and evolved over many centuries and millennia (see, e.g., [19-22]), respectively. Hierarchical command and control (C2) organizations in particular have been refined longitudinally (e.g., through iterative combat, training and doctrinal development, see e.g., [23]) to become very reliable and effective at the missions they were designed to accomplish. In contrast, evidence to support the putative benefits and comparative advantages proposed for Edge organizations has begun to emerge only very recently (e.g., see [24]), despite recognition that military practice is highly complex [25], can assume a wide variety of forms [26], and often involves high levels of interorganizational coordination (e.g., [27-30]) in which wholly hierarchal C2 structures would prove mismatched to the situational context.

Building upon early conceptualizations of Edge organizations (e.g., [1:20,38]), our campaign of experimentation has focused principally on the use of computational models, which McKelvey [31] has suggested as "constructive substitutes" (p. 771) to lab studies of organizations. This campaign began with a paper presented at the 2004 CCRTS conference [32]. In that paper, the relative advantages and disadvantages of computational experimentation were presented, and this, computational research method was described in terms of a complementary, empirical approach. The 2005 ICCRTS paper followed [33], in which more than 25, diverse, organizational forms were compared and analyzed, and the Edge organization form was shown to be theoretically distinct and uniquely differentiated from other organization forms grounded in both theory and practice. This 2005 paper also offered a theoretical discussion and set of hypotheses about the performance of Edge and Hierarchy organizational forms under different mission-environmental conditions, and provided some insight into relative characteristics and behaviors of Hierarchy and Edge organizations. The 2006 ICCRTS paper [34] expanded the study to specify and model four other, classic, theoretically grounded organization forms: Simple Structure, Professional Bureaucracy, Divisionalized Form (i.e., M-form, [35,36]), and Adhocracy [15,37]. We also employed computational experimentation to compare and contrast empirically the relative performance of Hierarchy and Edge organizational forms, using a multidimensional set of performance measures, under the mission-environmental conditions at two different points in history: 1) the Industrial Era, and 2) the 21st Century. Now, in a companion paper [38] to this present work, we are progressing systematically toward instantiation and analysis of the entire *organization design space* (i.e., in a contingency-theoretic sense) of organizational forms and mission-environmental contexts. This provides theoretically grounded, empirical results to complete the kind of "C2 approach space" conceptualized by Alberts and Hayes [39].

The research described in the present paper extends the campaign of computational experimentation outlined above through a series of laboratory experiments using the ELICIT multiplayer intelligence game [40]. ELICIT requires a team of subjects performing the roles of intelligence analysts to collaborate—in a network-centric, information-processing environment—via information sharing pertinent to a fictitious and stylized terrorist plot. The laboratory setting enables the customary levels of control and manipulation expected with experimentation, which provides for excellent reliability and internal validity of results [41]. Additionally, we use the results of our prior computational experiments to suggest in part a candidate set of research hypotheses for testing; to identify a candidate set of dependent variables for measurement; and to establish an empirical basis for further validation and calibration of our computational models in this, intelligence-focused, C2 environment. Hence this part of our campaign of experimentation is explicitly model-driven (see McKelvey [31] for a discussion of model-centered epistemology within organization science), and reveals another, novel, powerful approach to C2 research. Results should enable us to isolate some particularly powerful influences over and determinants of C2 efficacy—across organizational forms and contingency conditions—and to buttress the already solid foundation of external validation that supports our computational tools. Results should also help to illustrate the power of the ELICIT game to support compelling C2 research, and to contribute important, new knowledge in terms of both organization theory and C2 practice.

In the balance of the paper, we draw from the organization studies literature and prior computational experiments to motivate the set of research hypotheses examined through this study. We then detail our research design, and report in turn the key findings and results. The paper closes with a set of conclusions, recommendations for practice, and topics for future research along the lines of this campaign.

BACKGROUND

For more than a half century, Contingency Theory has retained a central place in organization studies research. Beginning with the seminal works by Burns and Stalker [42], Woodward [43], and Lawrence and Lorsch [44], organization theory has been guided by the understanding that no single approach to organizing is best in all circumstances. Moreover, myriad empirical studies (e.g., [43]; cf. [45, 46]) have confirmed and reconfirmed that poor organizational fit degrades performance, and many diverse organizational forms (e.g., Bureaucracy, see [69]; M-Form, see [35]; Clan, see [47]; Network, see [48]; Platform, see [49]; Virtual, see [50]) and configurations (e.g., Machine Bureaucracy, Simple Structure, Professional Bureaucracy, Divisionalized Form, Adhocracy, see [15]) have been theorized to enhance fit across an array of contingency factors (e.g., age, environment, size, strategy, technology).

In most of this research, the concept *organizational fit* has been treated in a relatively static manner, with a particular organizational form prescribed to fit well in a particular contingency context. For instance, *organizational environment* has been studied extensively as a powerful contingency factor (e.g., [42,51,52]), with alternate environmental characteristics (e.g., *comprehensibility, predictability*) related contingently with different organizational forms (e.g., *craft, engineering*, see [53]). Indeed, organization scholars have come to understand well how various organizational forms should and do vary to fit diverse environmental contexts.

However, organizational scholars (e.g., [54-56]) have noted widely that the environmental contexts of many modern organizations are not static. Rather, organizational environments can change rapidly and unpredictably, due to multiple factors such as globalization [57], technology [58, 59], hypercompetition [60], knowledge-based innovation [61], and mounting competition from co-evolutionary firms [62], and others. Hence an organization that achieves good fit with its environment at one point in time may not be able to retain such fit longitudinally, unless it changes structure in order to maintain fit—dynamically—across changing environmental conditions.

Indeed, an organization facing a constantly changing environment could fall into a condition of continuous (disruptive) change [63], or it might take the opposite approach, striving instead toward a single form that is flexible and robust to environmental change [64]. Alberts and Hayes [1,39] refer to such latter organizational form in terms of *agility.* In either case—and in most cases in between—leaders' and policy makers' focus on static organizational fit is incommensurate with the dynamics of contingent organization demanded by disruptive environmental change [65:Ch. 9].

The campaign of computational experimentation summarized above has addressed this issue directly, examining systematically the comparative performance of various organizational forms across abruptly changing environmental conditions. In essence, we are looking to identify the best organizational

fit for abruptly and disruptively changing environments. This campaign leads us to a set of model-driven research hypotheses meriting further testing through experimentation with human subjects. In particular, Orr and Nissen [34] conclude the following from their computational experimentation that compares Edge and Hierarchy organizational forms. Each of the hypotheses summarized below derives from Alberts and Hayes [1], and most include quotations to point the interested reader directly to the original motivation.

> *H0. Edge organizations can outperform Hierarchy organizations in demanding mission environmental contexts.*

Through computational experimentation, the Edge organization is shown to outperform the Hierarchy in the less-familiar, less-predictable, more-challenging environment referred to as the "21st Century Era." The previous authors conclude that the agility of this Edge form enables it to be more robust to demanding mission-environmental changes. This omnibus, null hypothesis is supported strongly by the results of the prior study.

> *H1. "Power to the Edge is the correct response to the increased uncertainty, volatility, and complexity associated with [21st century] military operations" [1:6].*

Similar to the omnibus hypothesis summarized above, manipulation of the organizational environment in computational experiments provides considerable support for this hypothesis. The Edge organization exhibits considerably greater agility, and hence is more robust to the challenges and demands of the 21st Century Era than the Hierarchy (e.g., consider how most, current, military C2 is organized) is.

> *H2. "The correct C2 approach depends on [five] factors": 1) shift from static/trench to mobile/maneuver warfare; 2) shift from cyclic to continuous communications; 3) volume and quality of information; 4) professional competence; and 5) creativity and initiative [1:19].*

Similar to manipulation of the organizational environment, the previous authors demonstrate that improving the network architecture and enhancing professional competency increase organizational performance considerably. However, this result pertains to the Edge and Hierarchy organizational forms alike. Hence improving network architecture and enhancing professional competency exert performance-enhancing effects across organizational forms, supporting elements 2) and 3) in the hypothesis stated above.

> *H3. "Given a robustly networked force, any one of the six effective command and control philosophies proven useful in the Industrial Era is possible" [1:32].*

The network architecture manipulation addresses this hypothesis in part, and the previous authors find evidence that improving network architecture increases organizational agility, and makes the organization more robust to challenges and demands of the 21st Century Era. However, their computational models do not represent each of six different C2 philosophies explicitly; hence support for this hypothesis is limited.

> *H4. People who work together, over time, and learn to operate in a "post and smart-pull" environment, will outperform similarly organized and capable people who do not.*

The professional competency manipulation addresses this hypothesis in large part, but the network architecture manipulation plays some role too (e.g., post and smart-pull environment). When focusing on professional competency effects, which include people working together over time, the previous authors find substantial support for this hypothesis. A worthwhile companion to the experimentation discussed in this piece could be exploration of alternative information dissemination techniques, such as "smart push" and others.

> H5. "The more uncertain and dynamic an adversary and/or the environment are, the more valuable agility becomes" [1:124].

Manipulation of the organizational environment addresses this hypothesis in part, and results above in terms of comparisons across abrupt environmental changes provide considerable support for this hypothesis. The Edge organization exhibits considerably greater agility, and hence is more robust to the uncertainties and dynamics of the 21st Century Era than is the Hierarchy.

> H6. "An organization's power can be increased without significant resource expenditures" [1:172].

This hypothesis is difficult to assess via computational results developed by the previous authors, for they do not represent resource expenditures explicitly, nor do they have variables to measure *organizational power*. However, individual, agent-level empowerment within an organization can be operationalized using the previous computational techniques by varying the level of professional competence that an agent holds relative to a particular task, as well as manipulating the probability that at agent seeks guidance from another in the event that an exception, or problem, is generated and noted. Indeed, the kinds of network architecture effects represented in their model demand huge resource investments in global communications infrastructure. Such investments provide some evidence against this hypothesis. Alternatively, the kinds of professional competency effects represented in their model do not demand large resource investments, as simply changing organizational policy to reduce job and personnel turnover can bring about considerable improvements in knowledge flows—and in turn organizational performance.

To summarize the results from computational experimentation, empirical evidence suggests that the novel, poorly understood, Edge organizational form outperforms the traditional, well-known Hierarchy across abrupt environmental shifts (H0). The Edge organization exhibits considerably greater agility (H1, H5) than the Hierarchy does, which makes it more robust to the challenges and demands of abrupt environmental change. Additionally, improving network architecture and enhancing professional competency increase organizational performance considerably, but this result pertains to the Edge and Hierarchy organizational forms alike (H2, H3, H4). However, whereas network architecture enhancements demand huge resource investments in global communications infrastructure, professional competency improvements do not (H6); hence the latter may represent a more prudent focus of attention and resources than the former does.

In terms of our current experimentation with people in the laboratory, we focus principally upon the omnibus hypothesis (H0) from above pertaining to organizational form, and we continue to concentrate on comparison between the Edge and Hierarchy. This appears to represent the most pressing issue in terms of leaders and policy makers, who must organize enterprises to fit well in the currently changing environment. This issue offers considerable theoretical insight as well, for the organization studies field continues to search for agile organizational forms. Restating this hypothesis in terms appropriate for human experimentation in the laboratory:

> *Hypothesis 1. People working together in an Edge organization will outperform those who perform the same work in a Hierarchy.*

Additionally, we focus on the professional competency results from above, for this appears to be a cost-effective approach to increasing the performance of any organizational form. Summarized simply:

> *Hypothesis 2. Organizations comprised of people with greater professional competence will outperform those with less-competent people, regardless of organizational form.*

Finally, expanding upon the model-driven hypotheses above, we draw from the literature on knowledge management and organizational learning (e.g., see Nissen book) to hypothesize that organizations—regardless of form—will learn over time and through task repetition, and that Edge organizations will learn more quickly than Hierarchies do:

> *Hypothesis 3. Performance of an Edge or Hierarchy organization will increase over time and through task repetition.*

Hypothesis 4. Performance of an Edge organization will increase more quickly than that of a Hierarchy.

RESEARCH DESIGN

In this section, we summarize the research design used to guide this series of laboratory experiments. Building directly upon the work accomplished by Parity [40], we employ the ELICIT multiplayer intelligence game to examine how people working together on an information-sharing and –processing task perform across organizational configurations. As summarized above, ELICIT requires a team of subjects performing the roles of intelligence analysts to collaborate—in a network-centric, information-processing environment—via information sharing pertinent to a fictitious and stylized terrorist plot. We begin by describing this ELICIT environment, and then outline the subjects, protocols, controls, manipulations and measurements used for experimentation.

ELICIT Environment

The intelligence game involves a fictitious terrorist plot, about which a set of 68 informational clues called "factoids" have been developed. Each factoid describes some aspect of the plot, but none is sufficient to answer all of the pertinent questions (i.e., who, what, where, when). The factoids are distributed among the 17 players in a series of steps: each player receives two clues initially, followed by one after five minutes of play and another after ten minutes have elapsed. The factoid distribution is designed so that no single player can solve the problem individually, and so that the team of players cannot solve the problem until after the final distribution. In other words, the players must collaborate to solve the problem, and they are required to do so for a minimum of ten minutes. Evidence from previous experiments (e.g., [40]) suggests that play requires substantially more time (e.g., an hour or more).

The ELICIT game is played via a client-server software application that operates on a computer network. The server application controls the game, interfaces with each of the 17 client applications, and maintains a log of all actions taken via the server and client machines. When the game is started, the server assigns pseudonyms to the players, and directs them to instructions describing the ELICIT software and rules for playing the game. When all of the subjects have read the instructions, and indicated that they are ready to play, the server distributes the initial set of factoids to the players according to their pseudonyms.

Subjects play the game via client applications on separate, networked computer workstations. Each subject has access to a set of five functions supported by the client: 1) List, 2) Post, 3) Pull, 4) Share, and 5) Identify. The List screen displays all factoids that a particular player has received. For instance, after the initial distribution, a player's List screen would display the two factoids distributed by the server. Post enables a player to have one or more factoids displayed on a common screen that can be viewed by other players. This represents one of two mechanisms for sharing information in the game (e.g., verbal and like communication is prohibited generally in most experiment protocols). Pull represents the complement to Post, as a player can display on his or her List screen common information that has been posted. These post-pull functions are associated with four, separate screens, each corresponding to the pertinent questions (i.e., who, what, where, when) regarding the terrorist plot; that is, one screen includes information regarding who (e.g., which terrorist organization) might be involved, another includes information regarding what (e.g., which target might be attacked), and so forth for information regarding where and when the attack might occur. Share represents the second mechanism for sharing information in the game, and enables players to send factoids directly to one another. Finally, Identify represents the manner in which subjects communicate their "solutions" to the problem, indicating via the software their conclusions regarding the pertinent questions (i.e., who, what, where, when) regarding the terrorist plot.

Multiple versions of the game have been created, each of which is structurally similar but distinct. For instance, each version includes 17 players (and pseudonyms) and a set of 68 factoids. However, the factoids—and hence details of the terrorist plot—are unique to each version. Hence the potential exists to play the game multiple times, even with the same group of subjects. Although time-consuming and tedious, additional, structurally equivalent versions of the game can be created as well. At the present time, four different versions have been created and shared.

After the game has completed—the protocol for determining when the end of the game occurs is discussed below—players close their client applications, the moderator shuts down the server application, and researchers begin to analyze the transaction data captured by the server in text-file logs. Such data include time stamped entries for nearly every activity in the networked ELICIT environment, including, for instance, when and which factoids are distributed to each player, when and which factoids are posted to which common screens, when and which common screens are viewed by each player, when and which factoids are shared between each player, and the time stamped results of each player's Identify attempt.

The game requires considerable cognitive and collaborative effort to play well (i.e., identify the pertinent details of a terrorist plot), but such effort is within the capabilities of many people and groups. For instance, the authors have played the game multiple times for pilot tests.

Subjects

Subjects in this experiment represent a combination of (mostly) masters and PhD students and (a few) faculty members in a graduate school of operational and information sciences at a major US university. Subjects are grouped into three sections: 1) Group A is comprised principally of PhD students in information science; 2) Group B is comprised principally of masters students enrolled in an advanced C2 course; and Group C is comprised principally of masters students enrolled in an introductory C2 course.

Subjects range in age from 22 to 62 years (μ = 34.8, σ = 8.46), and possess between 1 and 38 years of work experience (μ = 11.14, σ = 8.42). All subjects have undergraduate college degrees, and 46% have graduate degrees. Hence this group of subjects is representative in part of the kinds of relatively experienced and well-educated people who serve as professional intelligence analysts, particularly in national intelligence agencies. Further, all of the subjects have direct military or government service, and some have worked professionally in military or government intelligence organizations. Hence this group of subjects is representative also in part of the kind of military and government employees who serve as professional intelligence analysts. This representative sample serves to enhance the external validity of the study.

However, none of the subjects works currently as a professional intelligence analyst, and none of the three groups of subjects has worked together previously in an intelligence capacity. In this regard, the laboratory introduces some artificiality into the experiment. Additionally, despite the considerable level of realism designed into the ELICIT game, the information-sharing and -processing task is limited intentionally, so that people can play the game within an hour or two, and the networked-computer, ELICIT-mediated task environment does not enable all of the same kinds of media-rich communication modalities (e.g., telephone, video teleconference, face-to-face interpersonal and group interaction) likely to be found in operational intelligence organizations in the field. These factors serve to limit the external validity of the study. Limitations such as these are inherent within laboratory experimentation [32], and call for the use of other, complementary research methods (e.g., fieldwork, see [66]).

Protocols

Subjects are pre-assigned to play specific roles (e.g., as identified via pseudonyms) in the game, and to the extent possible, each subject plays the same role in every experiment session. In this particular experiment, subjects are pre-assigned to roles based upon their level of work experience. This is similar to the manner in which professional analysts are assigned to specific roles in operational intelligence organizations in the field, and hence helps to ground this experiment though conformance to practice. This approach contrasts a bit with that of randomized assignment imposed in some prior studies (cf. [40]), emphasizing our concern for realism over replication.

Subjects read about the experiment, and consent formally to participate in it. When all ELICIT clients have connected with the server, subjects sit down at the appropriate workstations, are informed verbally about the nature of the experiment, and are asked to read a set of instructions pertaining to both the experiment and the ELICIT environment. The instructions for Group A subjects are included in Appendix A for reference. Subjects are encouraged to ask questions throughout this process. When subjects have read the instructions, and have had their questions answered satisfactorily, they indicate via the ELICIT client that they are ready to begin.

In this particular experiment, each of the three subject groups participates separately (e.g., on a different day of the week), and each group participates in a total of four experiment sessions, each time playing a different version of the game (i.e., Versions 1 – 4). Each of the four experiment sessions is spaced roughly one week apart. This provides time for subjects to reflect upon the game, and to interact with one another outside of the laboratory (e.g., as collaborating professional intelligence analysts do), but given that the subjects have many responsibilities outside of the laboratory experiments, this provides time also for subjects to forget about specific aspects of each session (e.g., as multitasking professional intelligence analysts do). Hence some learning and forgetting outside of the laboratory environment takes place between experiment sessions. The specific schedule of play is described under manipulations below.

Subjects are instructed not to reveal their pseudonyms to one another during the game. Indeed, they are instructed not to talk or communicate with one another during the game via any mechanism outside of the two summarized above (i.e., post-pull, share). This simulates the kind of globally distributed, network-centric environment in which much intelligence work takes place operationally today. Additionally, subjects are allowed to send handwritten "postcards" directly to one another at periodic intervals. Postcards contain the same information associated with an Identify function (i.e., who, what, where and when details). This enriches the communication media available to the subjects beyond the artificially limiting factoid distribution enabled by the ELICIT software. To preserve anonymity, subjects send such postcards via the Experiment Moderator, who shuffles and delivers them to their intended recipients. Hence the sender of a postcard knows only the pseudonym of the receiver, and vice versa. In addition to enriching the communication media, such postcards also capture in part the mental models of subjects at various points of game play. A total of one postcard is allowed at each interval, with four or five intervals, coinciding approximately with the 15-, 25-, 35-, 45- and 55-minute marks in the game.

Subjects are given incentives to play the game well, as participation and performance are factored into the evaluation of students' coursework. Subjects are given incentives also for personal gain (e.g., a "point" is awarded for an individual person that identifies the plot correctly in the shortest period of time) as well as for group gain (e.g., a "point" is awarded for all members of the team that identify the plot correctly in the shortest period of time). This is intended to mimic the dual nature of incentives that exist in professional intelligence environments, where people must cooperate for the organization to perform well, but who also compete against one another for limited rewards such as wage increases, promotions, desirable job assignments, and like intrinsic and extrinsic factors. The incentive structure is thus somewhat analogous to the profit -sharing incentive system described by Groves [67]. Specifically, of the 44 team-individual reward strategies identified by Cacioppe [68], the game incentive structure provided public recognition (R10), praise (R11), feedback (R12), team-building (R19) and team attention (R20). Cacioppe [68] describes these reward and recognition strategies as falling between extrinsic and intrinsic rewards, and specifically ascribes their utility for the two phases of the team life cycle most critical to the experiment—establishing itself (stage 2) and performing the task (stage 3).

Each subject is instructed to use the Identify function only once during game play. This represents the manner in which *formal* conclusions about terrorist plots in practice are taken very seriously, and how they impact the organization (e.g., an operational organization may declare a state of emergency in preparation for or response to a suspected terrorist plot) in operational intelligence units. Hence each player in the game is expected to wait until he or she is relatively confident about the plot before sending an "official" notice. Alternatively, the use of postcards above allows subjects to exchange the same information informally with select other players. This represents the manner in which *informal* hypotheses are discussed and compared frequently within operational intelligence organizations.

The game can end in either of two ways: 1) when all players make their identification, or 2) when the Moderator must end the game due to time constraints. Generally, subjects are not told the results of the game (e.g., plot details) until after all four versions of the game have been played. This represents in part the kind of equivocality inherent in intelligence work: analysts are rarely certain about any suspected plot, and many are required to work on multiple plots either simultaneously or sequentially. Again, we go to considerable lengths to enhance the realism of the game—and hence external validity of the experiment results.

Finally, multiple instruments are administered to the subjects, at various points in time during the series of experiments. None of these instruments is administered during game play. They are described in the measurements section below.

Controls

As noted above, each subject is pre-assigned a specific role to play, and is intended to play such specific role through each version of the game. As noted above also, each version of the game is structurally equivalent, and both the ELICIT software and physical laboratory environments are invariant across experiment sessions. Further, via the instruments administered to the subjects and enacted within the ELICIT environment, researchers have the ability to control for myriad factors (e.g., personality, information-sharing, experience) *ex-post* to the experiment sessions. In general, we strive to control every aspect of the environment and experiment that is not manipulated expressly as described below. To the extent possible, we also matched teams for gender, Service, military rank, and age, achieving the greatest uniformity available between Groups B and C.

Manipulations

The manipulations center on the research hypotheses motivated and summarized above. Recall that the first hypothesis addresses the comparative performance of Edge and Hierarchy organizational forms. To test this hypothesis, subjects are assigned to experimental manipulations designed to represent the environments corresponding to these different organizational forms. We summarize each independently, and then outline the manipulation sequence across the series of experiment sessions. No specific manipulations are associated with the second hypothesis. Rather, we intend to gauge professional competence of the subjects outside of the game play, and to seek correlation and understanding via *ex-post* analysis. The other two hypotheses that address learning are addressed via the same Hierarchy-Edge manipulations described above.

Hierarchy

In the Hierarchy organization manipulation, subjects are assigned to play roles within a three-level, functional, hierarchical organization as depicted in Figure 1.

An overall leader (i.e., labeled “1”) is responsible for the intelligence organization as a whole, and has four functional leaders (i.e., labeled “2,” “6,” “10,” “14”) reporting directly. Each such leader in turn has three analysts (e.g., labeled “3,” “4,” “5”) reporting directly, and is responsible for one set of details associated with the terrorist plot. For instance, Subleader 2 and team would be responsible for the “who” details (e.g., which terrorist organization is involved) of the plot, Subleader 6 and team would be responsible for the “what” details (e.g., what the likely target is), and so forth for “when” and “where.” Subjects are shown this organization chart, told of their responsibilities within the organization, and provided with a short description of the hierarchy as an organizational form.

Additionally, the ELICIT software limits subjects’ Post and Pull access to specific common screens within this manipulation. Specifically, those players in the “who” group, for instance, are allowed to Post to and Pull from only one of the four common screens (i.e., the “who” screen) noted above. Comparable restrictions apply to players in the other three functional groups. The only exception applies to the Leader 1, who has post-pull access to all four common screens. Further, we limit postcards to immediate superiors and subordinates within the organization. These manipulations reinforce the functional and hierarchical nature of the Hierarchy organizational form represented.

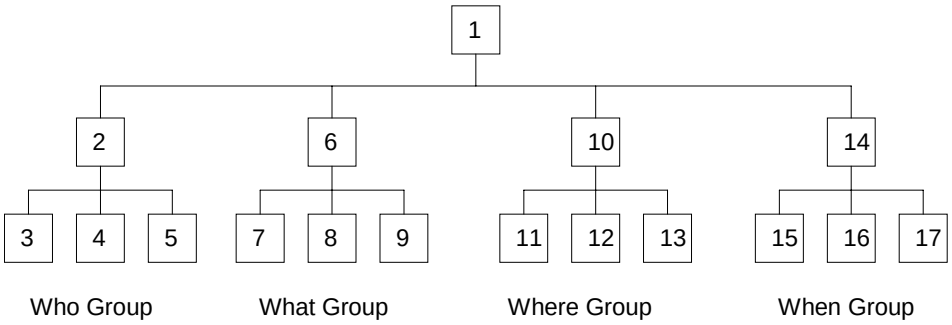

Figure 1: Hierarchy Organization

Alternatively, players are allowed to use the Share function to send factoids to any of the 16 other players in the entire organization. This serves to capture the "flattening" effect of e-mail and like, now-ubiquitous communication modes that enable peer-to-peer collaboration across formal organizational boundaries. We note, however, that such Share function is limited to sharing factoids only: no free-form or other information can be exchanged in this direct manner.

In terms of the game ending, in this manipulation, the game ends when all the players identify the plot details, or when the game times out. However, the incentive structure ensures such that players *other* than the leader receive individual recognition *if and only if* his or her pre-selected leader identifies the plot correctly and in less time than the other two teams. This represents the manner in which leaders of many hierarchical organizations speak for the organization as a whole, and it captures the important information-sharing task of ensuring that such leader is informed well.

Edge

In the Edge organization manipulation, there are no pre-assigned leaders or functional groups established in advance of the experiment. Rather, consistent with current Edge conceptualizations, the group is leaderless and without form—what Mintzberg terms *Adhocracy*. As noted above, the players are pre-assigned to specific roles (i.e., pseudonyms) within the game, but the various roles reflect no hierarchical or functional differences from one another. As with the hierarchy manipulation above, subjects are told about this organizational arrangement, and are provided with a short description of the Edge as an organizational form. We characterize the nature of this Edge manipulation in Figure 2.

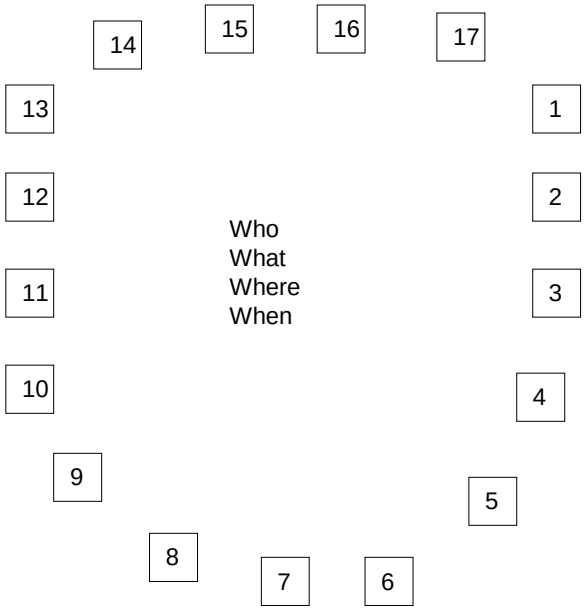

Figure 2 Edge Organization

Without an overall leader or functional groups, subjects must decide for themselves who works on which aspects of the problem, and who posts, pulls and exchanges information with whom. With this manipulation, the ELICIT software does not limit subjects' Post and Pull access to specific common screens; that is, in contrast to the hierarchy manipulation above, any player can post to and pull from any of the four common screens (i.e., "who," "what," "when," "where"). In further contrast, any player can send a postcard to any other player, albeit within the same format, frequency and number constraints established for the hierarchy manipulation. Consistent with the other manipulation is the Share function, through which any player can share factoids directly with any other.

In terms of the game ending, in this manipulation, the game ends when all players Identify the plot details, or when the game times out. This represents the manner in which flat, leaderless organizations require some consensual decision making, and it captures the important information-sharing task of ensuring that all participants are informed well. To ensure comparability with the hierarchy results, however, after the game has completed, participants are asked to elect *an emergent leader*, and this subject's game performance (e.g., evidenced via the Identify function) is used for comparison with that of the leader (i.e., Leader 1) in the hierarchy manipulation.

Manipulation Sequence

Each of the three subject groups is assigned to a unique manipulation sequence as summarized in Table 1, and each group plays all four versions of the game once (i.e., each group plays a total of four times). Group A plays according to the Edge manipulation all four times. Because we know relatively little about Edge organizations—particularly how they form and learn over time—this manipulation provides longitudinal data for exploration. Groups B and C play twice each in the Hierarchy and Edge manipulations, but the order of play is reversed. This reduces potential confounding from learning effects associated with order of play. These groups also play twice within each manipulation (e.g., twice in Hierarchy, then twice in Edge) before reversing. This allows two experiment sessions for learning within a particular organizational form to occur. The contrast between Group-B and –C performance reveals between-subjects effects; the contrast between Hierarchy and Edge manipulations reveals both within- and between-subjects effects; and both individual and organizational learning over time reveals within-subjects effects. As a note, the individual player represents the primary unit of analysis, but both individual and organizational levels of analysis are considered in this experiment.

Group	Session 1 V4	Session 2 V3	Session 3 V2	Session 4 V1
A - PhD	E	E	E	E
B - Advanced C2	H	H	E	E
C - Introductory C2	E	E	H	H

Key:
V1 - V4: ELICIT Version 1 - 4
H: Hierarchy manipulation
E: Edge manipulation

Table 1: Manipulation Sequence

Measurements

The first hypothesis addresses comparative organizational performance of Hierarchy and Edge organizations. In this experiment, *performance* is operationalized as a two-dimensional dependent variable comprised of: 1) time to identify plot details correctly; and 2) fraction of players who identify correctly. This measurement construct is informed by our computational experiments, in which *speed* and *accuracy* (related to *risk*) reveal consistently insightful results. In the first component, *time* pertains to when the game ends as described above. This represents organizational performance in terms of speed. In the second component, we calculate the number of players who identify correctly—minus those who identify incorrectly—as a fraction of the total number (e.g., 17) of players. Since the Identify function requires four pieces of information (i.e., who, what, where, when), we score one point for each correct piece—minus one point for each incorrect piece. Hence each player can score a total of 4 points per experiment session, with a maximum organizational score of 68 (i.e., 17 x 4) out of 68 possible points (i.e., 100%) within each session. This represents organizational performance in terms of accuracy. Notice that performance along this dimension can be *negative*. As alluded to above, identifying a terrorist attack incorrectly (e.g., a false alarm) can be detrimental too.

The second hypothesis addresses professional competence. We capture demographic and experiential information (e.g., education, work experience, intelligence experience) from subjects in order to pre-assign them to roles in the ELICIT game. Such demographic information is used to correlate and understand the role and distribution of professional competence on individual and organizational performance. This knowledge inventory instrument is included in Appendix B for reference.

The third and fourth hypotheses address learning. We operationalize *learning* as the change in performance over time and repetition, and use the same, two-dimensional dependent variable summarized above. Specifically, we measure the change in performance across the four experiment sessions—blocking by organizational form.

RESULTS

We will report the results of this series of experiments in the final paper submission.

CONCLUSION

We will include conclusions in the final paper submission.

APPENDIX A – PARTICIPANT INSTRUCTIONS (GROUP A)

Instructions

You have been assigned to an Edge organization. Your goal is to identify details about an impending terrorist attack. You may communicate to other players in two ways: 1) sharing and posting factoids via the software posting factoids to websites, and 2) sending "postcards." You may also pull factoids from websites. Verbal communication is not permitted during the game.

Sharing, posting and pulling factoids via the software

The software supports two ways of informing group members about factoids you have "discovered." You can **Share** a factoid directly with another group member using the Share tab. You can also **Post** a factoid to or **Pull** a factoid from any website. Other group members can do the same.

There are four websites: Who, What, Where and When. Though these areas are called websites, the information display is provided by the experiment software and not by the Internet.

- Factoids in your inbox can be copied into your MyFactoids list by selecting the factoid and clicking on the **Add to MyFactoids** action.
- To **Share** a factoid, select the factoid from either your inbox or your MyFactoids list that you wish to share. Click on the **Share** action, and select the pseudonym of the person with whom you want to share. This sends the factoid to the selected player's inbox message list.
- To **Post** a factoid, select the factoid from your inbox or MyFactoids list. Click on the **Post** action, and select the website you wish to post to.
- To **Pull** a factoid, select the factoid you wish to copy from the website and click on the Add to MyFactoids action. The **Add to My Factoids** action can be used to copy a factoid from a website to your MyFactoids list.

Sending "Postcards"

Periodically during the experiment, you will be asked to send a "postcard" to one other player of your choosing. You do NOT have to send the postcards to the same player each time. The postcard should reflect your assessment of the attack details at that point in time. Your postcards must have the following format:

Postcard

From: <your pseudonym> Date:
To: <addressee's pseudonym> Time:

My assessment of the attack is:	Certainty			
Group: _____	High	Moderate	Low	None
Target: _____	High	Moderate	Low	None
Country: _____	High	Moderate	Low	None
Month: _____	High	Moderate	Low	None
Day: _____	High	Moderate	Low	None
Time of day: _____	High	Moderate	Low	None
Method of attack: _____	High	Moderate	Low	None

Other software tools

Some other tools are available to you in the software:

- To get a summary list of all the factoids in your MyFactoids list, click on the MyFactoids tab in the middle of your screen.
- To find out your role information and how other members of your group see you, click on the "How I'm seen" tab.
- To get a list of all the members in your group, with information about their role and country, click on the "What I see" tab.
- To access information from a team website, click on the website that you wish to view. To update the website with the latest information that has been posted to it, click on the Refresh action at the top of the screen, while viewing the website.

Identifying the Who, What, Where, and When of the Attack

When you think that you have identified the who, what, where and when of the adversary attack, click on the **Identify** tab at the top of your screen and enter free text messages that identify the who, what, where and when of an adversary attack. **Partial answers are accepted, but you may Identify only one time**.

- The who is a group (for example the blue group).
- The what is a type of target (for example an embassy or religious school or dignitary)
- The where is the country in which the attack will take place (for example Alphaland)
- The when is the month, day and time of day on which the attack will occur (for example December 15, at 3:00 a.m.)

During the game

During each experiment round, you are free to work on any aspect of the task.

Winning the Game

Once all the players have identified a solution and the surveys are complete, you will be asked to determine who emerged as the 'team leader' during this round. Your selection should reflect a group consensus. After the game has been played, you may talk amongst each other to select the emergent team leader. Verbal communication is not permitted during the game, but is permitted once all of the surveys are complete and you are selecting your emergent team leader.

The games are structured as a tournament that recognizes the contributions of both individuals and groups. You receive one individual point **if you identify the correct solution and your emergent group leader identifies the correct solution**. Your group receives a group point if your emergent **group leader identifies the correct solution**. After the four games are played, the points will be totaled. You can receive a maximum of four individual points during the tournament, and your group can receive a maximum of four group points. In the event of an individual tie (e.g., 11 players identify four correct solutions and the emergent group leader identifies the correct solution in all cases), the fastest individual average time to identify wins. In the event of a group tie (e.g., all group leaders identify the correct solution), the fastest average time for the group to identify will win. **Therefore, it is in your best interest to identify the correct solution as quickly as possible while also ensuring that your emergent group leader identifies the correct solution as quickly as possible.** You may only use the 'identify' function in the software one time.

Game Over

The game is over when all players have made their identification, or 60 minutes have elapsed (whichever is sooner). You will also be asked to complete a different short survey at the end of the experiment.

Summary

You have been assigned to an edge organization. This assignment affects how you can communicate with other players.

- Sharing factoids: You may share factoids with any player of your choosing, and you may share any single factoid as many times as you wish. Factoids are shared via the ELICIT software.
- Sending postcards: You may send two postcards to any player of your choosing at specified intervals.
- Posting to websites: You can post any factoid to any website of your choosing.
- Pulling from websites: You may pull factoids posted on any website.

You can refer to these instructions during the course of the experiment by clicking again on the URL in the moderator message.

When you have finished reading this important group background information and are ready to begin, click the Ready button in the upper left corner of your screen.

Thank you for playing, and good luck!

	Edge
I want to:	
Share a Factoid	Factoids can be sent to any other player via the software
Send a Postcard	Handwritten postcards can be sent to any other player
Post a factoid to a website	Factoids can be posted to any website via the software
Pull a factoid from a website	Factoids can be pulled from any website via the software

Table 2: Quick Reference Table -- Edge

Note 1: Instructions were adapted from those originally created by Parity Communications, Available: http://www.parityinc.net/proctor/group-A.htm.
Note 2: Groups B and C, as listed in Table 1, were provided short descriptions of Edge and Hierarchy organizations in their set of instructions.

Appendix B – Subject Demographics

ELICIT Knowledge Inventory Questionnaire

Directions
Please complete this questionnaire candidly. Your information will kept in confidence, and will be used for anonymous statistical analysis and reporting purposes only. If you have any questions or concerns, please consult the Experiment Moderator.

Your name: _____

Today's date: _____

1. What is your age in years? _____

2. How many years of work experience do you have since college graduation? _____

3. Please list each college degree, major, institution and date separately (e.g.,
BS, Economics, UC Berkeley, 2000
MS Information Sciences, Naval Postgraduate School, 2004)

_____

_____

_____

_____

4. How many years of military/government experience do you have? _____

5. In which military/government branch do you work (e.g., Army, Navy)? _____

6. What is your current rank (e.g., O4/LCDR, GS13)? _____

7. What is your area of greatest military expertise (e.g., artillery, aviation) _____

_____

8. How many years' experience do you have in this area? _____

9. How many years' experience in the intelligence field do you have? _____

10. What is the greatest number of people that you have supervised? _____

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