

14th ICCRTS

“C2 and Agility”

Title: Exploring the Effects of Individual Characteristics on Organizational Performance using the ELICIT Experimentation Platform

Topic 6: Modeling and Simulation

Authors: Christine Anderson, Danielle Wynn, Jimmie McEver, Mary Ruddy (Parity Communications)

Point of Contact: Christine Anderson

Name of Organization: Evidence Based Research, Inc.

Complete Address: 1595 Spring Hill Road, Suite 250 Vienna, VA 22182

Telephone: 703-893-6800

E-mail Address: anderson@ebrinc.com

Abstract

The Command and Control Research Program (CCRP) has been involved in experimentation activities to investigate the relationships between and among aspects of C2 approaches (the distribution of decision rights, patterns of interaction, the distribution of information), individual characteristics, and team characteristics and their consequences including shared information, shared awareness, and task performance. To conduct such research, the CCRP has enhanced the ELICIT (Experimental Laboratory for Investigating Collaboration, Information-sharing, and Trust) software platform to include software agents. As part of the agent design and development effort, data sets from existing human ELICIT trials were analyzed to best replicate the human behaviors.

This study will depict the processes and analyses undertaken to explore human characteristics using ELICIT transaction logs. We will discuss the statistical techniques, such as cluster analysis, used to characterize individuals, investigate how these characteristics (or combinations of characteristics) impact performance of different organizational structures (edge, hierarchy, etc), and explore possible correlations between these characteristics.

Background

The Command and Control Research Program (CCRP) is involved in experimentation activities to investigate the C2 impact of cognition and collaboration processes, the distribution of decision rights, patterns of interaction, the structures of information flow, and other net centric related concepts. The CCRP has sponsored the design and development of a software environment for conducting human-in-the-loop experiments focused on information- and social-domain phenomena. This experimental environment, named ELICIT (Experimental Laboratory for Investigating Collaboration, Information-sharing, and Trust) provides the community with the capability to analyze the cognitive and social impacts of C2 approach and organizational structure, primarily focusing on information sharing, trust, shared awareness, and task performance.

The ELICIT software platform has undergone major enhancements. The experiment can now be conducted using software agents in place of or in conjunction with human participants. A great deal of effort has been put forth to design agents with rule sets that closely mirror human behaviors observed in ELICIT trials.

Objectives

Over the past few years, the ELICIT experimentation environment has matured and gained a great deal of interest. With demand comes the desire for new capabilities such as the addition of software agents. Agent Based ELICIT (abELICIT)¹ will allow researchers the ability to conduct experiments rapidly and with fewer resources. In order to develop software agents that would replicate the actions and decisions of human participants the team had to develop rule sets and calculate delays associated with such actions. In doing so our team used data collected from twenty five human runs to calibrate human behaviors. As part of that work, we analyzed the ELICIT log files to determine individual characteristics, such as an individuals propensity to seek information, propensity to share information, and by what means do participants share.

The primary purpose of this work is to investigate how the human characteristics described above (or combinations of characteristics) impact performance of different organizational structures (edge, hierarchy, etc), and explore possible correlations between these characteristics. This research was conducted to inform abELICIT developers and ensure the proper design of an ELICIT software agent. This paper summarizes the statistical techniques utilized to conduct this analysis and demonstrates our findings.

What is ELICIT?

The baseline scenario of the ELICIT experimentation environment presents a group of seventeen players with an information distribution and assembly problem to explore how people share information and generate shared awareness. In the experimental scenario, subjects receive information about a future attack. Sixty eight factoids containing information related to the party

¹ Ruddy et al., *Instantiation of a Sensemaking Agent for use with ELICIT Experimentation*, 2009. 14th ICCRTS Washington DC.

carrying out the attack, the form the attack will take, the time of the attack, and the location of the attack, namely the who, what, when, and where of the problem are introduced into the system by the server operating the experiment. Two factoids are distributed to each participant at the start of the game. A third factoid is distributed to each participant after five minutes and a fourth after ten minutes. Each factoid contains key, supportive, or extraneous information; no factoid contains false information. The information is structured so that various sets of factoids combine to allow one of the four information areas to be solved.

The participant’s mission is to gain a sufficient amount of knowledge to solve or identify each of the four question areas by combining and sharing the information to which they have access. Each subject is able to transmit his known facts in two ways. Peer-to-peer sharing allows a participant to share a factoid directly with another participant. Factoids may also be broadcasted by posting a factoid to a commonly available website. Participants can check the websites and view posted factoids. The act of viewing a website is referred to as a pull, given the assumption that a participant views a website to search for factoids and extract information from postings. When a participant feels they have seen/collected enough factoids to develop an understanding of the solution, they can identify a four part answer. The number of ID attempts can be controlled by the experiment facilitator.

Networked Organization

The C2 approach for the series of experiments analyzed as part of this effort is designated prior to the start of each run. These organizational structures are either a traditional hierarchy and an edge or fully connected network. The control variables used in the experiment are expressed as part of these network structures. Each organization is made up of seventeen participants. Communication lines exist between participants (peer-to-peer) and between participants and websites. In each organizational structure, the peer-to-peer communication capabilities are the same; in other words, every participant can communicate directly with all other participants. However the two structures largely differ in website accessibility. In the hierarchy, participants are divided into four task groups each having access to only one website. The seventeenth participant in the hierarchy is the cross team coordinator or the commander who has access to all four task websites. Unlike the hierarchy, all participants in the edge network have access to all four task websites. Website accessibility is depicted in the diagrams below.

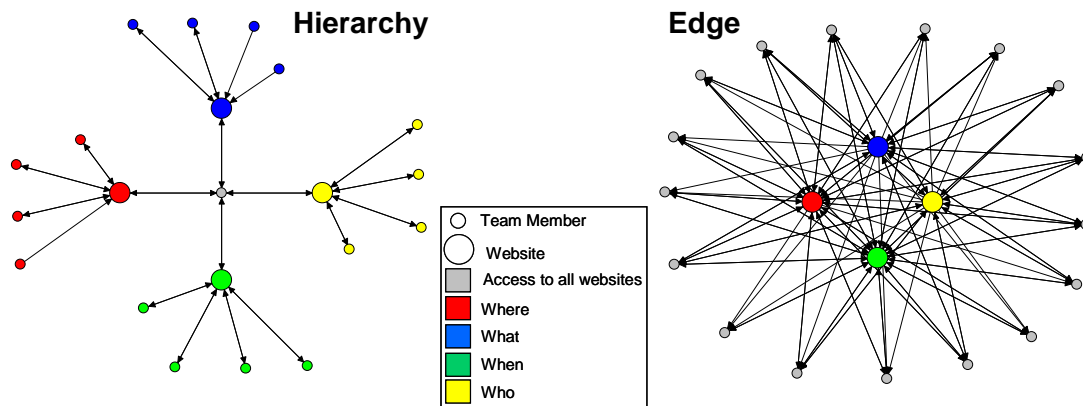


Figure 1. Website Access by Organization Type

Data Collection

An ELICIT experiment produces a transaction log which records all actions performed by participants using the software during the trial, timestamps each action, and documents metadata pertaining to the experiment itself (date, time, number of participants, factoid set, etc.). The transaction logs are text files which can be manipulated and parsed using data scripts to conduct statistical comparisons.

The analysis detailed in this paper was accomplished by leveraging data collected during twenty five past experimentation efforts to analyze factors affecting shared awareness. The human log files were parsed into time-phased data tables using Python^{TM2} scripts. Key data was then extracted for detailed review. JMP^{TM3} and ExcelTM were used to manipulate, visualize, calculate statistics and analyze the data.

The ELICIT Value Chain

The network structure within ELICIT enables information sharing, which allows individuals to develop situational awareness and facilitates mission effectiveness. In order to quantify the organizational structures and measure the behaviors described in the value chain depicted below, we identified a set of related metrics. The ELICIT behavior measures and indicators of awareness are listed to the right of the value chain.

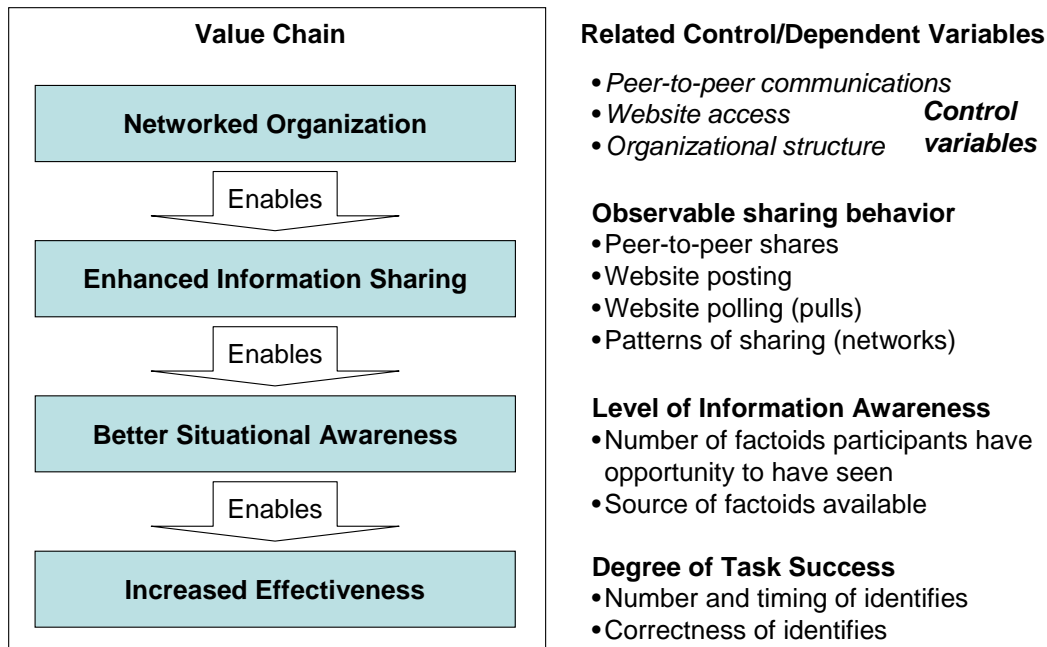


Figure 2. NCO Value Chain for ELICIT and Related Metrics

When possible, these metrics directly map to experimental data, otherwise indirect measures are used. Metrics are available for information dissemination behaviors, network characteristics, and

² G. van Rossum et al., Python Language Website, <http://www.python.org/>

³ JMP, Version 7. SAS Institute Inc., Cary, NC, 1989-2007

task success as listed above. This work primarily focuses on measures related to information sharing and awareness.

Analysis

To investigate human characteristics using the ELICIT transaction logs, EBR employed numerous processes and statistical techniques. These human characteristics include an individual’s sharing behaviors and how they seek out information within a trial run. Our team looked specifically at characterizing an individual’s Sharing Modality and Propensity to Share. Sharing Modality is the process by which an individual shares information; whether they broadcast information through the use of a website or if they have a greater propensity to share information with a single individual on a peer to peer level. Propensity to Share describes an individual’s tendency to share factoids with other participants. Based upon how frequently an individual visits a website(s), our team was also able to identify an individual’s Propensity to Seek.

Our team used the statistical technique of Clustering to assign interval settings for the Propensity to Share and Propensity to Seek metrics. This technique provides a method to group similar values and allows us to observe how the data clumps together.⁴ In our cluster analysis, our team used K-means clustering, which is an iterative clustering method for dealing with large data sets. K-means clustering starts with an estimate of cluster seed points, and then starts “alternately assigning points to clusters and recalculating cluster centers.”⁵

PROPENSITY TO SEEK

The Propensity to Seek levels were assigned based on the clustering results of the mean website revisit time for a given run and subject combination. This metric looks at how often an individual visits a website but does not indicate what sort of material or how much material the individual viewed upon visiting the website. This characteristic uses three intervals (Low, Moderate, and High) to group similar values.

Using JMP’s K-means cluster analysis, we can identify the interval settings to determine which data records fall into the appropriate intervals. A summary of the results is contained in the following table:

| Cluster | Count | Mean (Revisit Time) | Standard Deviation | Setting | Prevalence | Interval Setting |
|---------|-------|---------------------|--------------------|----------|------------|--------------------|
| 1 | 202 | 70.958833 | 28.0031991 | High | 53.30% | $p < 120$ |
| 2 | 151 | 169.084318 | 34.7107142 | Moderate | 39.84% | $120 \leq p < 260$ |
| 3 | 26 | 349.325779 | 78.8269672 | Low | 6.86% | $p \geq 260$ |

Table 1. Cluster Summary for Propensity to Seek

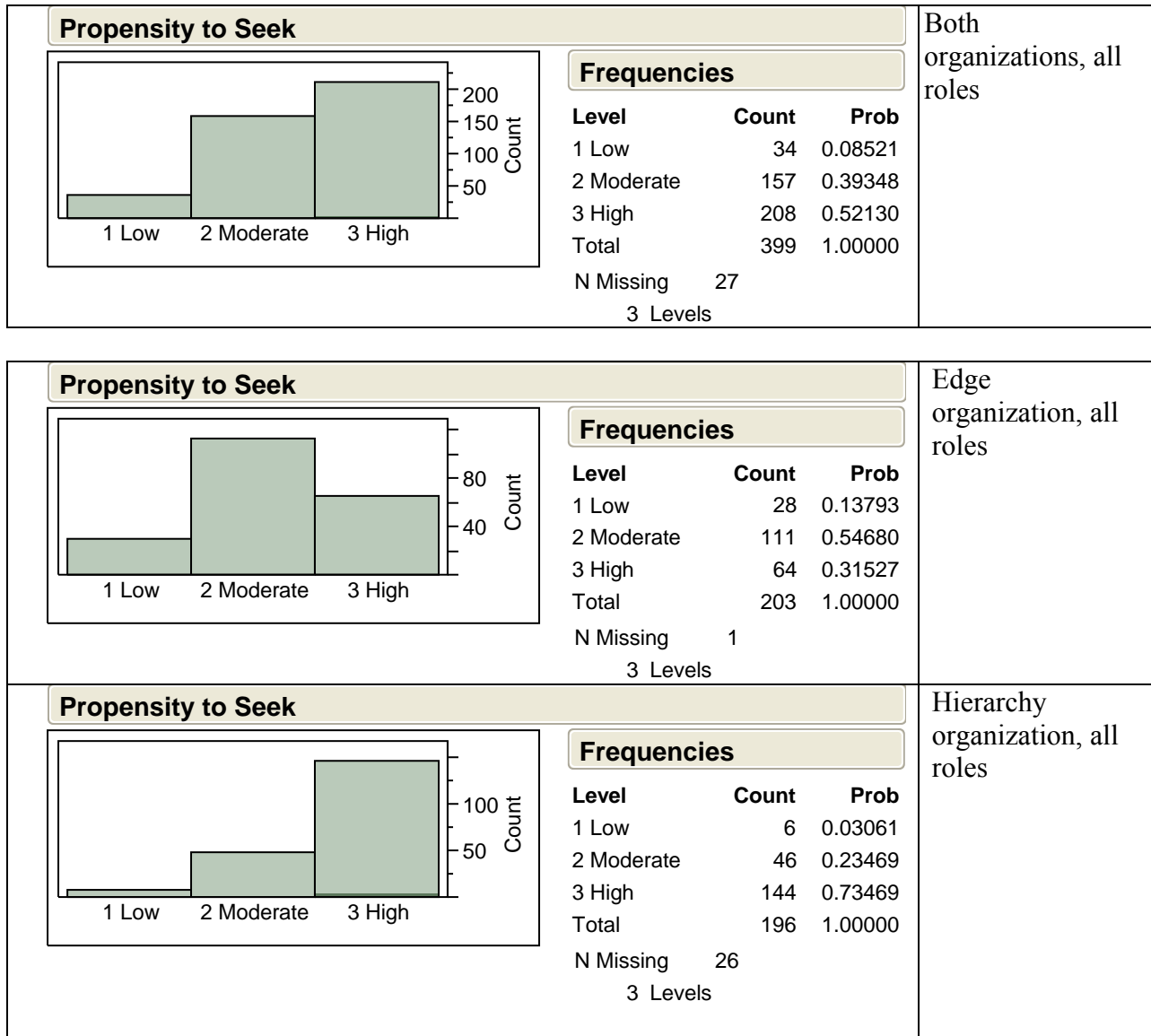
The majority of our observations (a run and subject combination) have a high or moderate propensity to seek and have a mean revisit time of 71 seconds or 169 seconds, respectively. This result indicates that individuals frequently seek out factoids throughout a trial run in an effort to identify the solution. Individuals with a high propensity to seek have a mean revisit time less

⁴ “Clustering” *JMP 8.0 Help*, SAS Institute Inc., Cary, NC, 2008.

⁵ *Ibid.*

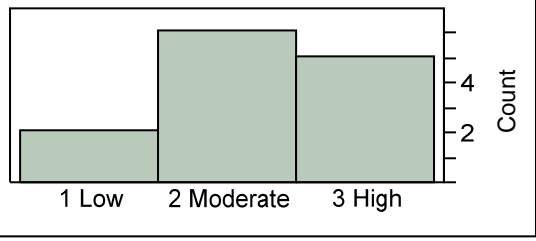
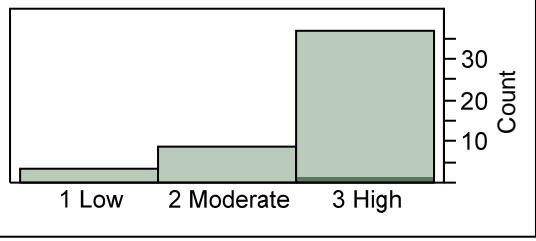
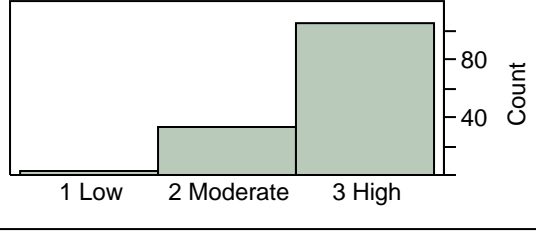
than 120 seconds (2 minutes), while individuals with a low propensity to seek have a mean revisit time greater than 260 seconds (over 4 minutes).

To further examine the behavior of the propensity to seek metric, the following distributions look at how the Propensity to Seek metric varies with an individual’s organization type and role. Throughout this study, we display the graphical results of our analysis from our statistical software JMP and provide an explanation of which organization and roles are included to the right side of the graph.



In the previous two charts, we examine the distributions of the Propensity to Seek metric by organization type. A larger proportion of Hierarchy subjects have a high propensity to seek versus subjects in the Edge organization where the majority of individuals have a moderate propensity to seek. The revisit time may be shorter in the Hierarchy runs as individuals in the Edge organization are given access to all four websites while all but one individual within the

Hierarchy only has access to only one website. Edge participants check more than one website with a greater amount of time passing before revisiting each site. Hierarchy members and team leaders track only one website and revisit often.

| <p>Propensity to Seek</p>  <p>Frequencies</p> <table border="1"> <thead> <tr> <th>Level</th> <th>Count</th> <th>Prob</th> </tr> </thead> <tbody> <tr> <td>1 Low</td> <td>2</td> <td>0.15385</td> </tr> <tr> <td>2 Moderate</td> <td>6</td> <td>0.46154</td> </tr> <tr> <td>3 High</td> <td>5</td> <td>0.38462</td> </tr> <tr> <td>Total</td> <td>13</td> <td>1.00000</td> </tr> <tr> <td>N Missing</td> <td>0</td> <td></td> </tr> </tbody> </table> <p>3 Levels</p> | Level | Count | Prob | 1 Low | 2 | 0.15385 | 2 Moderate | 6 | 0.46154 | 3 High | 5 | 0.38462 | Total | 13 | 1.00000 | N Missing | 0 | | <p>Hierarchy organization, Coordinator role</p> |
|--|-------|---------|------|-------|---|---------|------------|----|---------|--------|-----|---------|-------|-----|---------|-----------|----|--|---|
| Level | Count | Prob | | | | | | | | | | | | | | | | | |
| 1 Low | 2 | 0.15385 | | | | | | | | | | | | | | | | | |
| 2 Moderate | 6 | 0.46154 | | | | | | | | | | | | | | | | | |
| 3 High | 5 | 0.38462 | | | | | | | | | | | | | | | | | |
| Total | 13 | 1.00000 | | | | | | | | | | | | | | | | | |
| N Missing | 0 | | | | | | | | | | | | | | | | | | |
| <p>Propensity to Seek</p>  <p>Frequencies</p> <table border="1"> <thead> <tr> <th>Level</th> <th>Count</th> <th>Prob</th> </tr> </thead> <tbody> <tr> <td>1 Low</td> <td>3</td> <td>0.06383</td> </tr> <tr> <td>2 Moderate</td> <td>8</td> <td>0.17021</td> </tr> <tr> <td>3 High</td> <td>36</td> <td>0.76596</td> </tr> <tr> <td>Total</td> <td>47</td> <td>1.00000</td> </tr> <tr> <td>N Missing</td> <td>5</td> <td></td> </tr> </tbody> </table> <p>3 Levels</p> | Level | Count | Prob | 1 Low | 3 | 0.06383 | 2 Moderate | 8 | 0.17021 | 3 High | 36 | 0.76596 | Total | 47 | 1.00000 | N Missing | 5 | | <p>Hierarchy organization, Leader role</p> |
| Level | Count | Prob | | | | | | | | | | | | | | | | | |
| 1 Low | 3 | 0.06383 | | | | | | | | | | | | | | | | | |
| 2 Moderate | 8 | 0.17021 | | | | | | | | | | | | | | | | | |
| 3 High | 36 | 0.76596 | | | | | | | | | | | | | | | | | |
| Total | 47 | 1.00000 | | | | | | | | | | | | | | | | | |
| N Missing | 5 | | | | | | | | | | | | | | | | | | |
| <p>Propensity to Seek</p>  <p>Frequencies</p> <table border="1"> <thead> <tr> <th>Level</th> <th>Count</th> <th>Prob</th> </tr> </thead> <tbody> <tr> <td>1 Low</td> <td>1</td> <td>0.00735</td> </tr> <tr> <td>2 Moderate</td> <td>32</td> <td>0.23529</td> </tr> <tr> <td>3 High</td> <td>103</td> <td>0.75735</td> </tr> <tr> <td>Total</td> <td>136</td> <td>1.00000</td> </tr> <tr> <td>N Missing</td> <td>21</td> <td></td> </tr> </tbody> </table> <p>3 Levels</p> | Level | Count | Prob | 1 Low | 1 | 0.00735 | 2 Moderate | 32 | 0.23529 | 3 High | 103 | 0.75735 | Total | 136 | 1.00000 | N Missing | 21 | | <p>Hierarchy organization, Member role</p> |
| Level | Count | Prob | | | | | | | | | | | | | | | | | |
| 1 Low | 1 | 0.00735 | | | | | | | | | | | | | | | | | |
| 2 Moderate | 32 | 0.23529 | | | | | | | | | | | | | | | | | |
| 3 High | 103 | 0.75735 | | | | | | | | | | | | | | | | | |
| Total | 136 | 1.00000 | | | | | | | | | | | | | | | | | |
| N Missing | 21 | | | | | | | | | | | | | | | | | | |

In the last three charts, we notice the differences across the role types in the Hierarchy organization. The coordinator (or commander) role has a majority of individuals with a moderate propensity to seek, whereas both individuals in the leader and member role have a majority of individuals with a high propensity to seek. As explained above, one possible explanation for this outcome is that the coordinator has access to all four websites while the team leaders and members only have access to one website.

In calculating the cluster interval settings for Propensity to Seek, data pertaining to those participants who did not visit a website more than once were excluded.

PROPENSITY TO SHARE

As part of our analysis of sharing behavior, our team looked at an individual’s average Propensity to Share. This metric is calculated based on the number of posts an individual performed on factoids received through distribution, the number of shares an individual performed on factoids received through distribution, the subject’s organization type, and the number of websites a subject had access to. The formula used to calculate an individual’s propensity to share is:

$$\text{Propensity to Share} = \frac{(\# \text{ of posts})(\text{post reach}) + (\# \text{ of shares})}{(\# \text{ of websites accessible by subject})(\text{post reach}) + (\text{team size} - 1)}$$

The post reach and team size variables are constant based on the subject’s organization type and role. Post reach indicates the number of participants that have access to a given website. Team size can be defined in a hierarchy organization as a coordinator, a leader, and three members for a total size of five, while the edge organization consists of seventeen team members. The following formulas display these constants for each organization type and role combination:

Edge Organization

$$\text{Member} = \frac{(x)(16) + (y)}{(4)(16) + (16)}$$

Hierarchy Organization

$$\text{Coordinator} = \frac{(x)(4) + (y)}{(4)(4) + (4)}$$

$$\text{Leader} = \frac{(x)(4) + (y)}{(1)(4) + (4)}$$

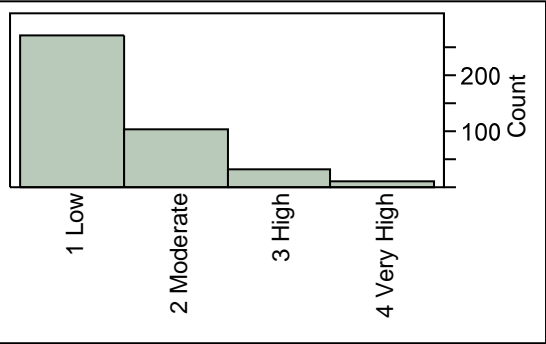
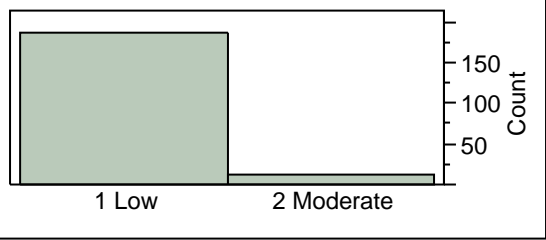
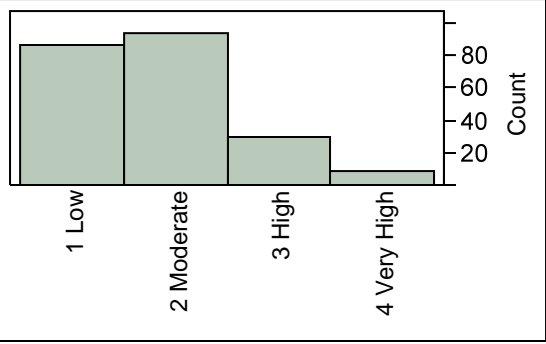
$$\text{Member} = \frac{(x)(4) + (y)}{(1)(4) + (3)}$$

To calculate the average propensity to share, the value was divided by four, or the number of distributed factoids the subject received. If a subject did not perform any sharing events, their Propensity to Share was not calculated. Using JMP’s clustering analysis function, we set the following interval settings in the cluster summary table below:


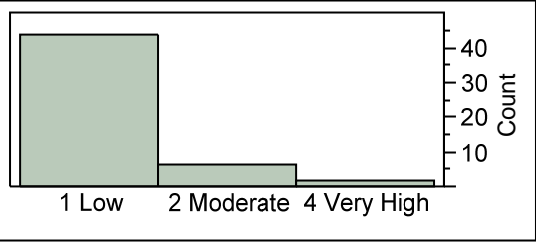
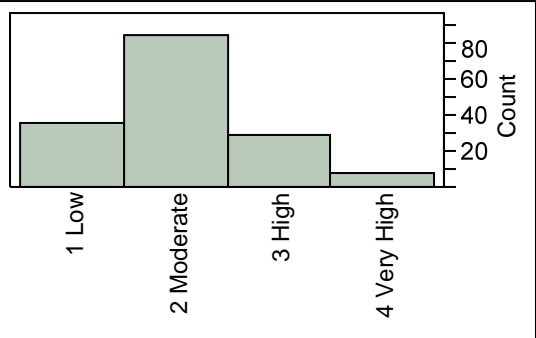
Cluster Summary for Propensity to Share

| Cluster | Count | Propensity to Share | Standard Deviation | Setting | Prevalence | Interval Setting |
|---------|-------|---------------------|--------------------|-----------|------------|------------------|
| 1 | 229 | 0.24835075 | 0.09585284 | Low | 63.43% | p < 0.47 |
| 2 | 96 | 0.70352958 | 0.12379198 | Moderate | 26.59% | 0.47 ≤ p < 0.97 |
| 3 | 28 | 1.2348852 | 0.1902041 | High | 7.76% | 0.97 ≤ p < 1.96 |
| 4 | 8 | 2.38169643 | 0.37928042 | Very High | 2.22% | p ≥ 1.96 |

Missing values in the following distributions indicate that an individual performed no sharing events within a run, and thus, no share modality setting could be determined for that run and subject combination. The following distributions look at the propensity to share based on organization type and an individual’s role.

| <p>Propensity to Share</p>  <p>Frequencies</p> <table border="1"> <thead> <tr> <th>Level</th> <th>Count</th> <th>Prob</th> </tr> </thead> <tbody> <tr> <td>1 Low</td> <td>268</td> <td>0.66010</td> </tr> <tr> <td>2 Moderate</td> <td>101</td> <td>0.24877</td> </tr> <tr> <td>3 High</td> <td>29</td> <td>0.07143</td> </tr> <tr> <td>4 Very High</td> <td>8</td> <td>0.01970</td> </tr> <tr> <td>Total</td> <td>406</td> <td>1.00000</td> </tr> <tr> <td>N Missing</td> <td>20</td> <td></td> </tr> <tr> <td colspan="3">4 Levels</td> </tr> </tbody> </table> | Level | Count | Prob | 1 Low | 268 | 0.66010 | 2 Moderate | 101 | 0.24877 | 3 High | 29 | 0.07143 | 4 Very High | 8 | 0.01970 | Total | 406 | 1.00000 | N Missing | 20 | | 4 Levels | | | <p>Both organization types and all roles. Missing values are those run and subject combinations that have no assigned Propensity to Share.</p> |
|--|-------|---------|------|-------|-----|---------|------------|-----|---------|--------|-----|---------|-------------|----|---------|----------|-----|---------|---|----|--|----------|--|--|--|
| Level | Count | Prob | | | | | | | | | | | | | | | | | | | | | | | |
| 1 Low | 268 | 0.66010 | | | | | | | | | | | | | | | | | | | | | | | |
| 2 Moderate | 101 | 0.24877 | | | | | | | | | | | | | | | | | | | | | | | |
| 3 High | 29 | 0.07143 | | | | | | | | | | | | | | | | | | | | | | | |
| 4 Very High | 8 | 0.01970 | | | | | | | | | | | | | | | | | | | | | | | |
| Total | 406 | 1.00000 | | | | | | | | | | | | | | | | | | | | | | | |
| N Missing | 20 | | | | | | | | | | | | | | | | | | | | | | | | |
| 4 Levels | | | | | | | | | | | | | | | | | | | | | | | | | |
| <p>Propensity to Share</p>  <p>Frequencies</p> <table border="1"> <thead> <tr> <th>Level</th> <th>Count</th> <th>Prob</th> </tr> </thead> <tbody> <tr> <td>1 Low</td> <td>183</td> <td>0.95313</td> </tr> <tr> <td>2 Moderate</td> <td>9</td> <td>0.04688</td> </tr> <tr> <td>Total</td> <td>192</td> <td>1.00000</td> </tr> <tr> <td>N Missing</td> <td>12</td> <td></td> </tr> <tr> <td colspan="3">2 Levels</td> </tr> </tbody> </table> | Level | Count | Prob | 1 Low | 183 | 0.95313 | 2 Moderate | 9 | 0.04688 | Total | 192 | 1.00000 | N Missing | 12 | | 2 Levels | | | <p>Edge organization, all roles</p> <p>No subjects with a “High” or “Very High” Propensity to Share</p> | | | | | | |
| Level | Count | Prob | | | | | | | | | | | | | | | | | | | | | | | |
| 1 Low | 183 | 0.95313 | | | | | | | | | | | | | | | | | | | | | | | |
| 2 Moderate | 9 | 0.04688 | | | | | | | | | | | | | | | | | | | | | | | |
| Total | 192 | 1.00000 | | | | | | | | | | | | | | | | | | | | | | | |
| N Missing | 12 | | | | | | | | | | | | | | | | | | | | | | | | |
| 2 Levels | | | | | | | | | | | | | | | | | | | | | | | | | |
| <p>Propensity to Share</p>  <p>Frequencies</p> <table border="1"> <thead> <tr> <th>Level</th> <th>Count</th> <th>Prob</th> </tr> </thead> <tbody> <tr> <td>1 Low</td> <td>85</td> <td>0.39720</td> </tr> <tr> <td>2 Moderate</td> <td>92</td> <td>0.42991</td> </tr> <tr> <td>3 High</td> <td>29</td> <td>0.13551</td> </tr> <tr> <td>4 Very High</td> <td>8</td> <td>0.03738</td> </tr> <tr> <td>Total</td> <td>214</td> <td>1.00000</td> </tr> <tr> <td>N Missing</td> <td>8</td> <td></td> </tr> <tr> <td colspan="3">4 Levels</td> </tr> </tbody> </table> | Level | Count | Prob | 1 Low | 85 | 0.39720 | 2 Moderate | 92 | 0.42991 | 3 High | 29 | 0.13551 | 4 Very High | 8 | 0.03738 | Total | 214 | 1.00000 | N Missing | 8 | | 4 Levels | | | <p>Hierarchy organization, all roles</p> |
| Level | Count | Prob | | | | | | | | | | | | | | | | | | | | | | | |
| 1 Low | 85 | 0.39720 | | | | | | | | | | | | | | | | | | | | | | | |
| 2 Moderate | 92 | 0.42991 | | | | | | | | | | | | | | | | | | | | | | | |
| 3 High | 29 | 0.13551 | | | | | | | | | | | | | | | | | | | | | | | |
| 4 Very High | 8 | 0.03738 | | | | | | | | | | | | | | | | | | | | | | | |
| Total | 214 | 1.00000 | | | | | | | | | | | | | | | | | | | | | | | |
| N Missing | 8 | | | | | | | | | | | | | | | | | | | | | | | | |
| 4 Levels | | | | | | | | | | | | | | | | | | | | | | | | | |

In the previous two charts, we notice the differences in the distributions of the Propensity to Share based on organization type. Individuals in the Edge organization mostly have a low propensity to share. In the Hierarchy organization, we see a lot more variation in the propensity to share.

| <p>Propensity to Share</p>  <p>Frequencies</p> <table border="1"> <thead> <tr> <th>Level</th> <th>Count</th> <th>Prob</th> </tr> </thead> <tbody> <tr> <td>1 Low</td> <td>8</td> <td>0.66667</td> </tr> <tr> <td>2 Moderate</td> <td>3</td> <td>0.25000</td> </tr> <tr> <td>3 High</td> <td>1</td> <td>0.08333</td> </tr> <tr> <td>Total</td> <td>12</td> <td>1.00000</td> </tr> <tr> <td>N Missing</td> <td>1</td> <td></td> </tr> </tbody> </table> <p>3 Levels</p> | Level | Count | Prob | 1 Low | 8 | 0.66667 | 2 Moderate | 3 | 0.25000 | 3 High | 1 | 0.08333 | Total | 12 | 1.00000 | N Missing | 1 | | <p>Hierarchy Organization, Coordinator Role</p> | | | |
|---|-------|---------|------|-------|----|---------|------------|----|---------|-------------|----|---------|-------------|----|---------|-----------|-----|---------|---|---|--|--|
| Level | Count | Prob | | | | | | | | | | | | | | | | | | | | |
| 1 Low | 8 | 0.66667 | | | | | | | | | | | | | | | | | | | | |
| 2 Moderate | 3 | 0.25000 | | | | | | | | | | | | | | | | | | | | |
| 3 High | 1 | 0.08333 | | | | | | | | | | | | | | | | | | | | |
| Total | 12 | 1.00000 | | | | | | | | | | | | | | | | | | | | |
| N Missing | 1 | | | | | | | | | | | | | | | | | | | | | |
| <p>Propensity to Share</p>  <p>Frequencies</p> <table border="1"> <thead> <tr> <th>Level</th> <th>Count</th> <th>Prob</th> </tr> </thead> <tbody> <tr> <td>1 Low</td> <td>43</td> <td>0.86000</td> </tr> <tr> <td>2 Moderate</td> <td>6</td> <td>0.12000</td> </tr> <tr> <td>4 Very High</td> <td>1</td> <td>0.02000</td> </tr> <tr> <td>Total</td> <td>50</td> <td>1.00000</td> </tr> <tr> <td>N Missing</td> <td>2</td> <td></td> </tr> </tbody> </table> <p>3 Levels</p> | Level | Count | Prob | 1 Low | 43 | 0.86000 | 2 Moderate | 6 | 0.12000 | 4 Very High | 1 | 0.02000 | Total | 50 | 1.00000 | N Missing | 2 | | <p>Hierarchy Organization, Leader Role</p> | | | |
| Level | Count | Prob | | | | | | | | | | | | | | | | | | | | |
| 1 Low | 43 | 0.86000 | | | | | | | | | | | | | | | | | | | | |
| 2 Moderate | 6 | 0.12000 | | | | | | | | | | | | | | | | | | | | |
| 4 Very High | 1 | 0.02000 | | | | | | | | | | | | | | | | | | | | |
| Total | 50 | 1.00000 | | | | | | | | | | | | | | | | | | | | |
| N Missing | 2 | | | | | | | | | | | | | | | | | | | | | |
| <p>Propensity to Share</p>  <p>Frequencies</p> <table border="1"> <thead> <tr> <th>Level</th> <th>Count</th> <th>Prob</th> </tr> </thead> <tbody> <tr> <td>1 Low</td> <td>34</td> <td>0.22368</td> </tr> <tr> <td>2 Moderate</td> <td>83</td> <td>0.54605</td> </tr> <tr> <td>3 High</td> <td>28</td> <td>0.18421</td> </tr> <tr> <td>4 Very High</td> <td>7</td> <td>0.04605</td> </tr> <tr> <td>Total</td> <td>152</td> <td>1.00000</td> </tr> <tr> <td>N Missing</td> <td>5</td> <td></td> </tr> </tbody> </table> <p>4 Levels</p> | Level | Count | Prob | 1 Low | 34 | 0.22368 | 2 Moderate | 83 | 0.54605 | 3 High | 28 | 0.18421 | 4 Very High | 7 | 0.04605 | Total | 152 | 1.00000 | N Missing | 5 | | <p>Hierarchy Organization, Member Role</p> |
| Level | Count | Prob | | | | | | | | | | | | | | | | | | | | |
| 1 Low | 34 | 0.22368 | | | | | | | | | | | | | | | | | | | | |
| 2 Moderate | 83 | 0.54605 | | | | | | | | | | | | | | | | | | | | |
| 3 High | 28 | 0.18421 | | | | | | | | | | | | | | | | | | | | |
| 4 Very High | 7 | 0.04605 | | | | | | | | | | | | | | | | | | | | |
| Total | 152 | 1.00000 | | | | | | | | | | | | | | | | | | | | |
| N Missing | 5 | | | | | | | | | | | | | | | | | | | | | |

Our analysis of the propensity to share in the Hierarchy organization shows variation amongst different role types. The majority of individuals in a coordinator or leader role have a low propensity to share while the majority of individuals in the member role have a moderate propensity to share.

SHARE MODALITY

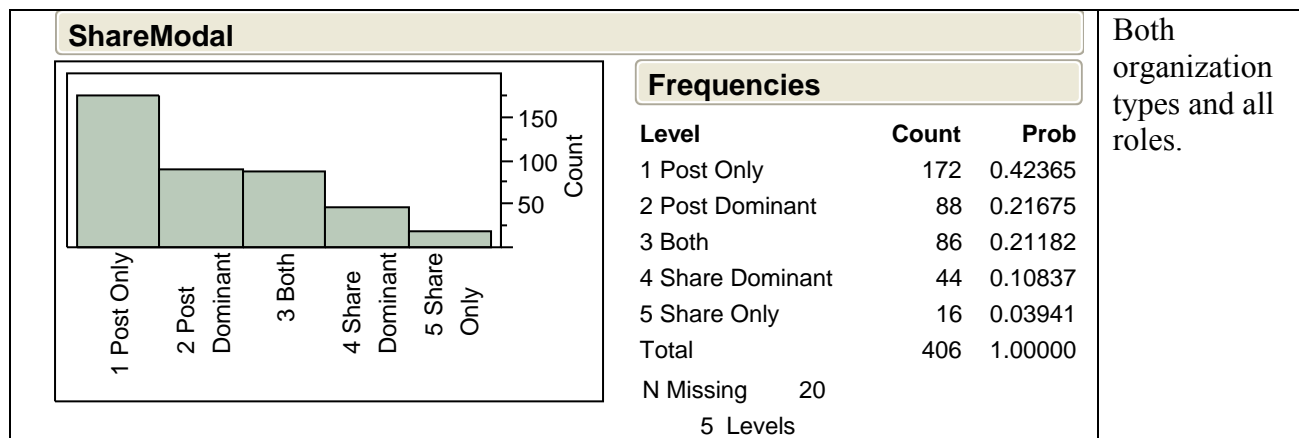
An individual’s sharing modality characterizes the process by which an individual shares information. A rule set was used to determine which of the five possible settings an individual may have. Reviewing only actions performed on the four factoids that an individual receives directly from the ELICIT server as part of the distribution wave, the following sharing behavior types were observed:

1. **Share Only** indicates all sharing observations were direct peer to peer shares

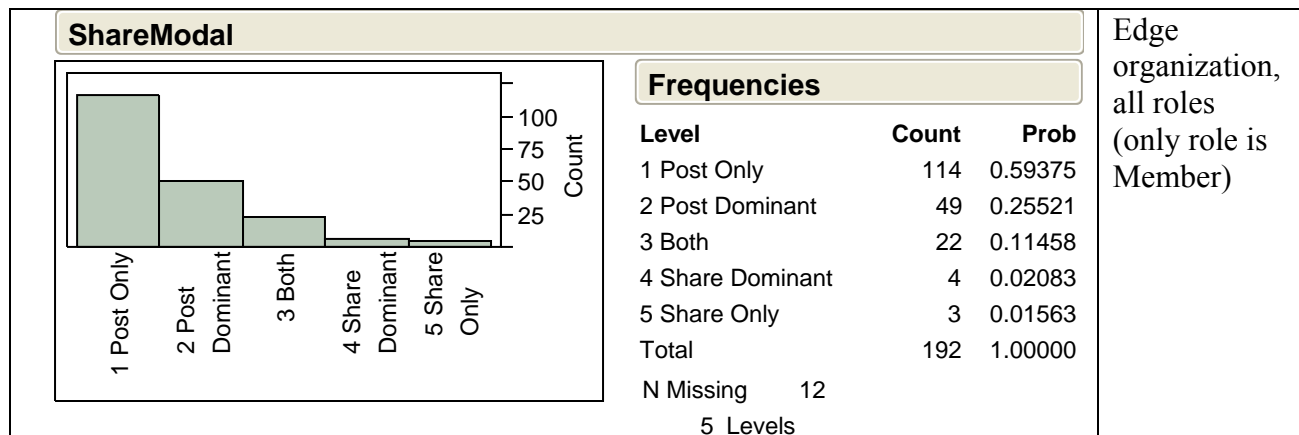
2. **Share Dominant** means that at least one peer to peer only behavior was observed on the distributed facts and no post only behavior observed
3. **Both** indicates that sharing observations include both posting and sharing. In cases where post only and peer to peer only behaviors were observed this setting was assigned.
4. **Post Dominant** indicates that at least one post only behavior was observed and no peer to peer only behavior observed
5. **Post only** indicates all sharing observations were post only

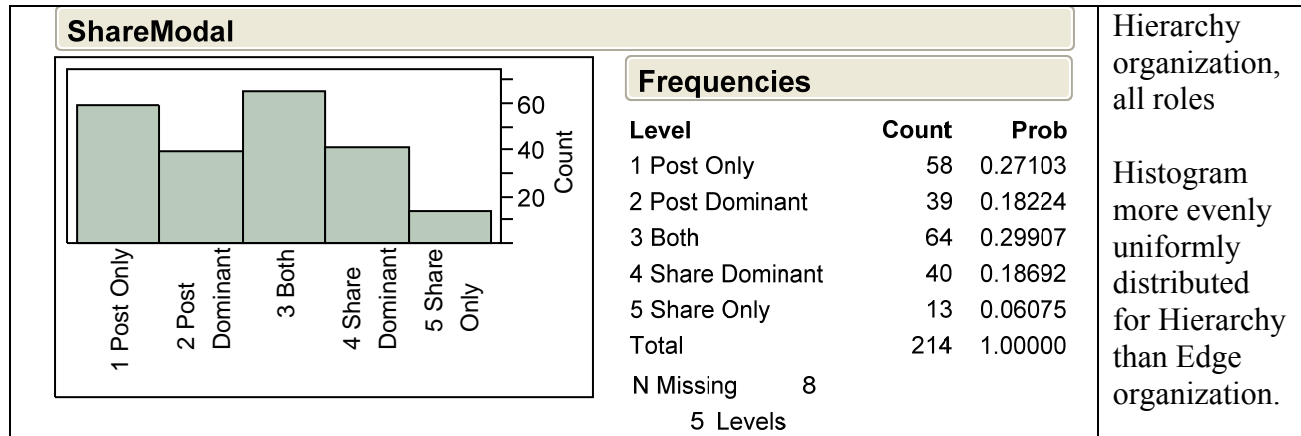
DISTRIBUTIONS OF SHARE MODALITY SETTING

Missing values in the following charts indicate that a subject did not perform any sharing events with their received distributed factoids within a run, and thus, no share modality setting could be applied.

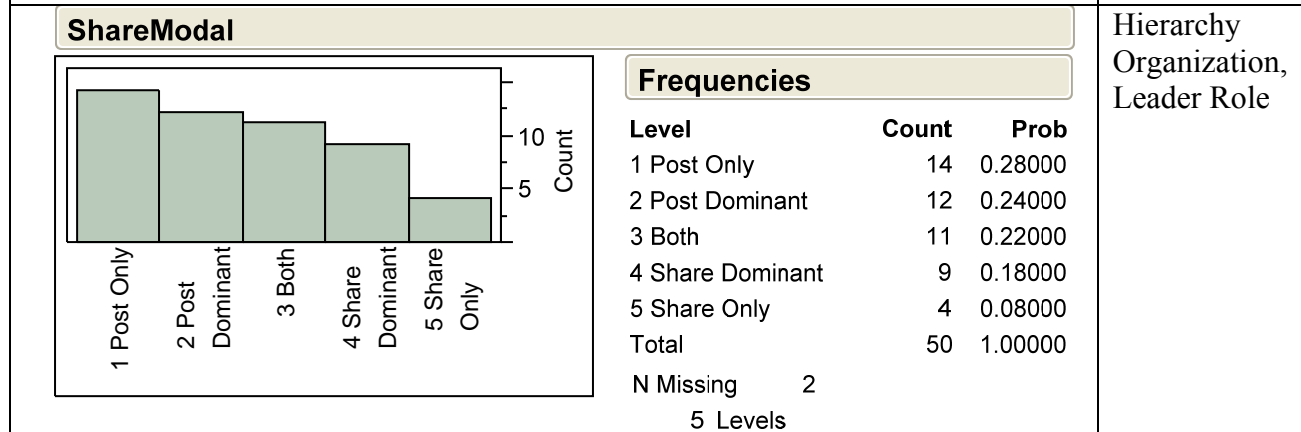
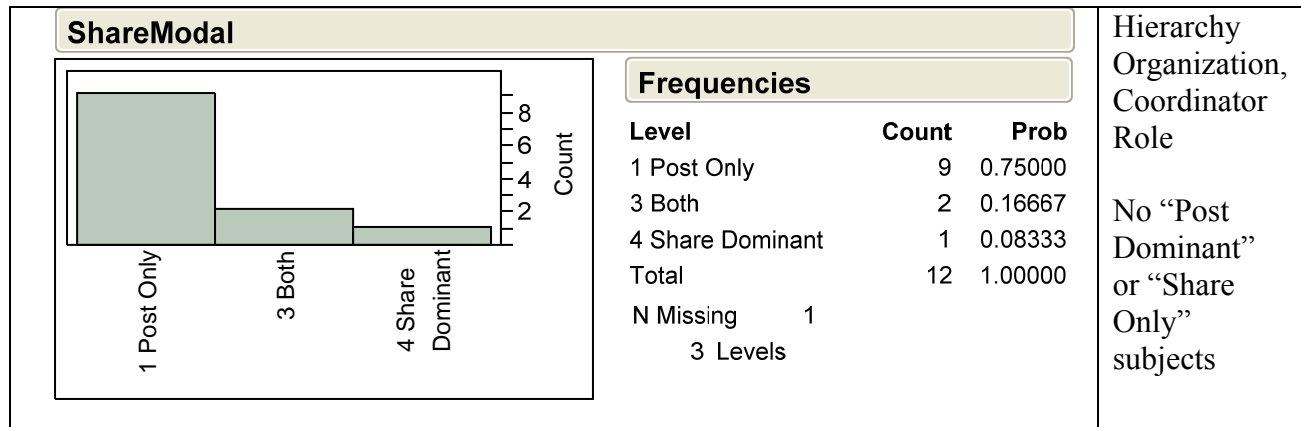


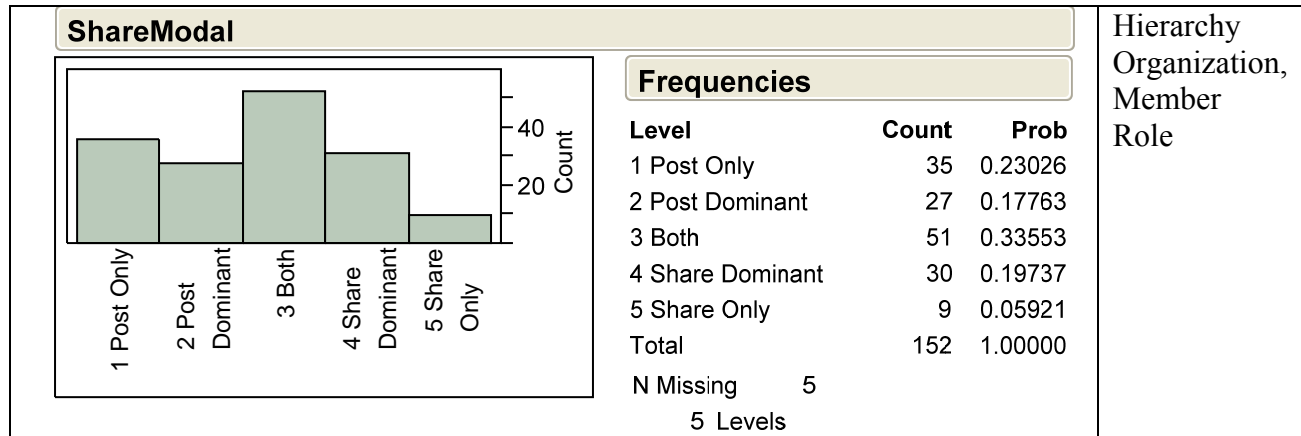
Individuals across both organizations appear to be more likely to post information (Post Only or Post Dominant) than share information (Share Only or Share Dominant). 64% of individuals post information, whereas only 15% share information.





The previous two charts look at the distributions of the share modality in the Edge and Hierarchy organization. We see that there is more variation in the share modality settings in the Hierarchy organization, as we see greater numbers of peer-to-peer sharing than in the Edge organization.





We see that the majority of coordinators (commanders) in the hierarchy organization have a share modality of post only, whereas the share modality setting has greater variation for those in a leader or member role.

Correlations Between Characteristics

As part of our effort to characterize individual behaviors, we believe that sharing behavior may be correlated to a subject's propensity to seek. We conducted a contingency analysis and chi-squared test to examine if there is any correlation between these metrics. A low R^2 value for a Chi-Squared test (less than 0.05) indicates that the factors are not correlated.

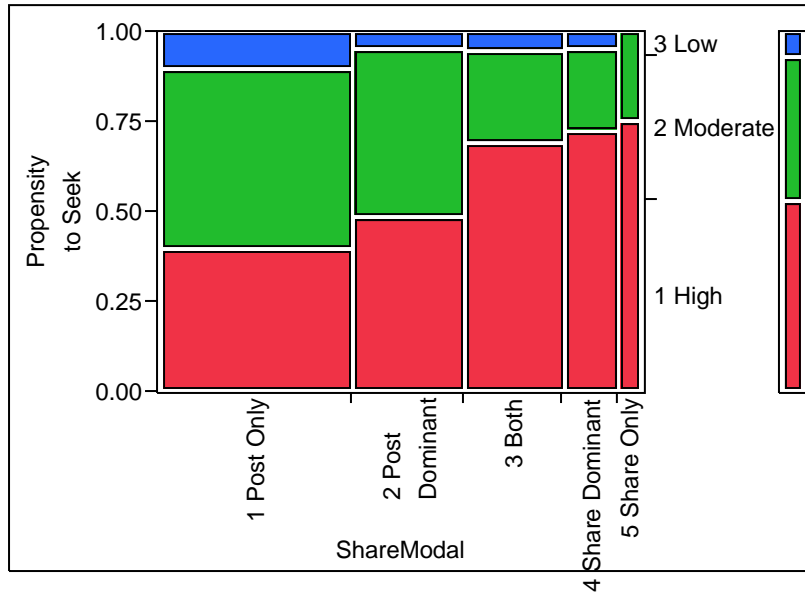
CORRELATION BETWEEN PROPENSITY TO SEEK AND SHARE MODALITY

In our first test, we look at all the subjects in both organizations to see if there is any correlation between Share Modality and Propensity to Seek. The results are as follows:

Both Edge and Hierarchy Organizations:

Contingency Analysis of Propensity to Seek By ShareModal

Mosaic Plot



Contingency Table

| | Propensity to Seek | | | |
|------------------|--------------------|------------|-------|-------|
| | 1 High | 2 Moderate | 3 Low | |
| Count | | | | |
| Total % | | | | |
| 1 Post Only | 61 | 76 | 16 | 153 |
| | 16.09 | 20.05 | 4.22 | 40.37 |
| 2 Post Dominant | 43 | 41 | 4 | 88 |
| | 11.35 | 10.82 | 1.06 | 23.22 |
| 3 Both | 54 | 20 | 4 | 78 |
| | 14.25 | 5.28 | 1.06 | 20.58 |
| 4 Share Dominant | 32 | 10 | 2 | 44 |
| | 8.44 | 2.64 | 0.53 | 11.61 |
| 5 Share Only | 12 | 4 | 0 | 16 |
| | 3.17 | 1.06 | 0.00 | 4.22 |
| | 202 | 151 | 26 | 379 |
| | 53.30 | 39.84 | 6.86 | |

Tests

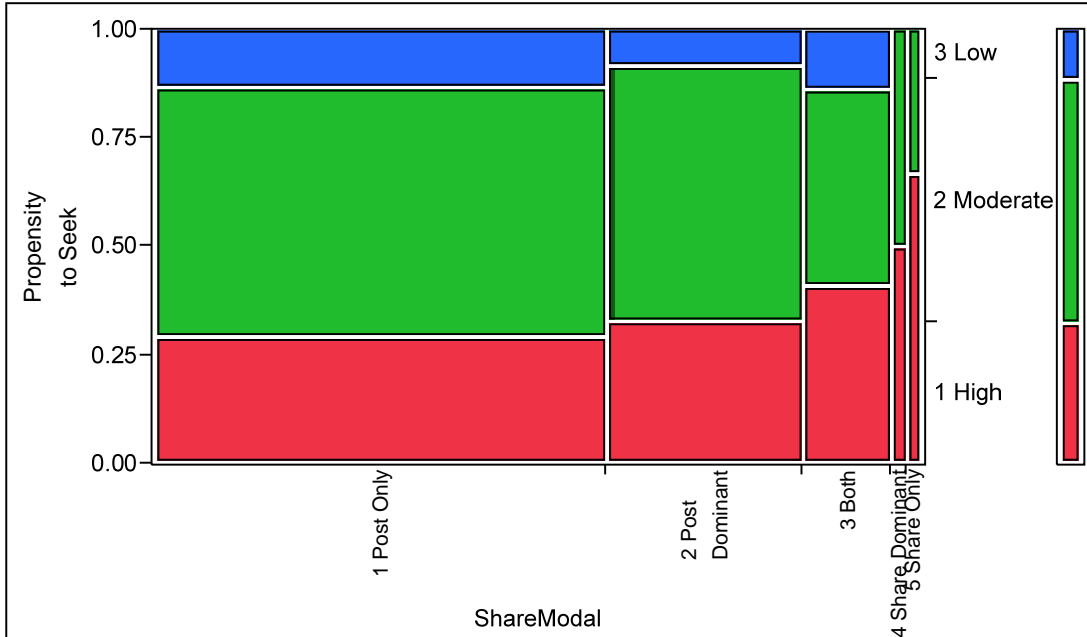
| | N | DF | -LogLike | RSquare (U) |
|------------------|-----|----|------------------|----------------------|
| | 379 | 8 | 16.723097 | 0.0498 |
| Test | | | ChiSquare | Prob>ChiSq |
| Likelihood Ratio | | | 33.446 | <.0001* |
| Pearson | | | 31.888 | <.0001* |

An R^2 value of 0.0498 suggests that an individual's share modality is independent of their propensity to seek. Since we suspect individuals in different organization types exhibit different behaviors, we run the same chi-squared tests for each organization type, Edge and Hierarchy:

Edge Organization:

Contingency Analysis of Propensity to Seek By ShareModal Org Type=Edge

Mosaic Plot



Contingency Table

| | | Propensity to Seek | | | |
|------------------|-----------------|--------------------|------------|-------|-------|
| | | 1 High | 2 Moderate | 3 Low | |
| ShareModal | Count | | | | |
| | Total % | | | | |
| | 1 Post Only | 33 | 65 | 15 | 113 |
| | | 17.28 | 34.03 | 7.85 | 59.16 |
| | 2 Post Dominant | 16 | 29 | 4 | 49 |
| | | 8.38 | 15.18 | 2.09 | 25.65 |
| 3 Both | 9 | 10 | 3 | 22 | |
| | 4.71 | 5.24 | 1.57 | 11.52 | |
| 4 Share Dominant | 2 | 2 | 0 | 4 | |
| | 1.05 | 1.05 | 0.00 | 2.09 | |
| 5 Share Only | 2 | 1 | 0 | 3 | |
| | 1.05 | 0.52 | 0.00 | 1.57 | |
| | 62 | 107 | 22 | 191 | |
| | 32.46 | 56.02 | 11.52 | | |

Tests

| N | DF | -LogLike | RSquare (U) |
|-----|----|-----------|-------------|
| 191 | 8 | 2.7227504 | 0.0152 |

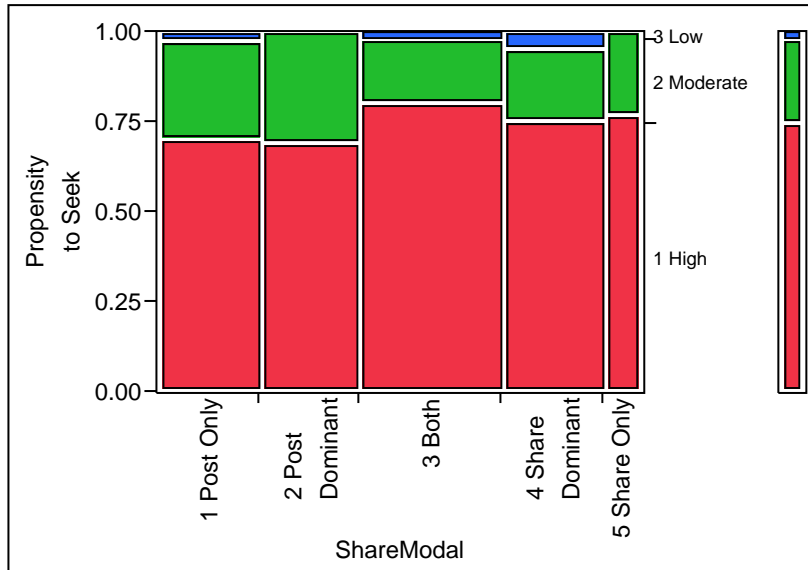
| Test | ChiSquare | Prob>ChiSq |
|------------------|-----------|------------|
| Likelihood Ratio | 5.446 | 0.7091 |
| Pearson | 4.860 | 0.7724 |

Warning: 20% of cells have expected count less than 5, ChiSquare suspect.

For Hierarchy Organization:

Contingency Analysis of Propensity to Seek By ShareModal Org Type=Hierarchy

Mosaic Plot



Contingency Table

| ShareModal | Propensity to Seek | | | Count | Total % |
|------------------|--------------------|------------|-------|-------|---------|
| | 1 High | 2 Moderate | 3 Low | | |
| 1 Post Only | 28 | 11 | 1 | 40 | 14.89 |
| 2 Post Dominant | 27 | 12 | 0 | 39 | 14.36 |
| 3 Both | 45 | 10 | 1 | 56 | 23.94 |
| 4 Share Dominant | 30 | 8 | 2 | 40 | 15.96 |
| 5 Share Only | 10 | 3 | 0 | 13 | 5.32 |
| | 140 | 44 | 4 | 188 | 74.47 |
| | | 23.40 | 2.13 | | |

Tests

| | N | DF | -LogLike | RSquare (U) |
|------------------|-----------|------------|-----------|-------------|
| | 188 | 8 | 3.0084800 | 0.0250 |
| Test | ChiSquare | Prob>ChiSq | | |
| Likelihood Ratio | 6.017 | 0.6453 | | |
| Pearson | 5.364 | 0.7181 | | |

Warning: 20% of cells have expected count less than 5, ChiSquare suspect.

The Chi-Squared tests for both organization types return an R^2 value that is less than 0.05, suggesting that there is no correlation between the Propensity to Seek and Share Modality.

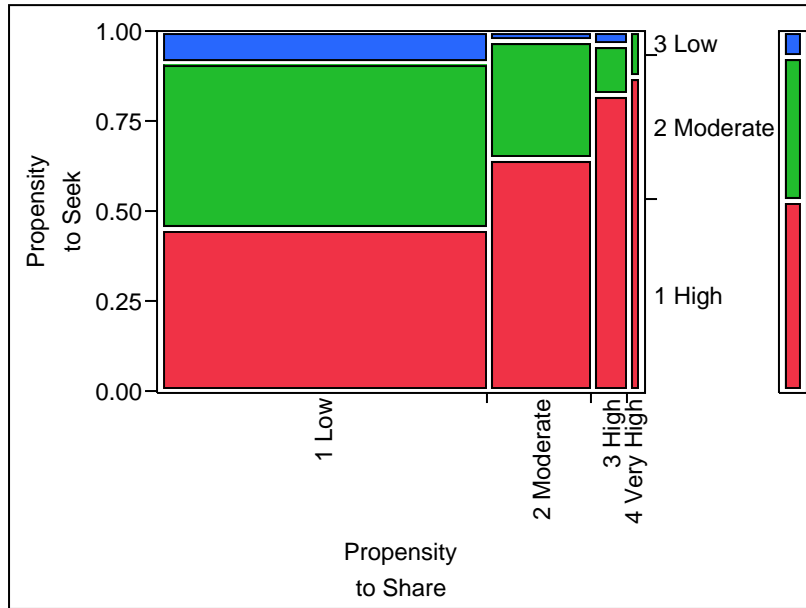
CORRELATION BETWEEN PROPENSITY TO SEEK AND PROPENSITY TO SHARE

A low R^2 value for the Chi-Squared test indicates that the factors are not correlated. All R^2 values are less than 0.05, suggesting that there is no correlation between the Propensity to Seek and Propensity to Share settings.

Both Edge and Hierarchy Organizations:

Contingency Analysis of Propensity to Seek By Propensity to Share

Mosaic Plot



Contingency Table

| | | Propensity to Seek | | | |
|---------------------|------------|--------------------|------------|-------|-------|
| | | 1 High | 2 Moderate | 3 Low | |
| Propensity to Share | Count | 118 | 119 | 23 | 260 |
| | Total % | 31.13 | 31.40 | 6.07 | 68.60 |
| | 1 Low | | | | |
| | 2 Moderate | 53 | 27 | 2 | 82 |
| | 3 High | 13.98 | 7.12 | 0.53 | 21.64 |
| 4 Very High | 24 | 4 | 1 | 29 | |
| | 6.33 | 1.06 | 0.26 | 7.65 | |
| | 7 | 1 | 0 | 8 | |
| | 1.85 | 0.26 | 0.00 | 2.11 | |
| | 202 | 151 | 26 | 379 | |
| | 53.30 | 39.84 | 6.86 | | |

Tests

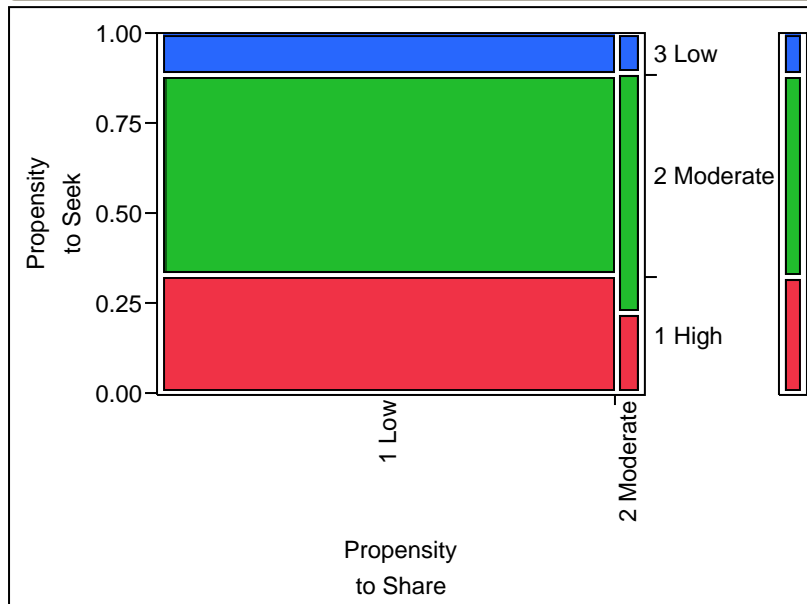
| | N | DF | -LogLike | RSquare (U) |
|------------------|-----------|------------|-----------|-------------|
| | 379 | 6 | 14.333118 | 0.0427 |
| Test | ChiSquare | Prob>ChiSq | | |
| Likelihood Ratio | 28.666 | <.0001* | | |
| Pearson | 26.099 | 0.0002* | | |

Warning: 20% of cells have expected count less than 5, ChiSquare suspect.

For Edge Organization:

Contingency Analysis of Propensity to Seek By Propensity to Share Org Type=Edge

Mosaic Plot



Contingency Table

| | | Propensity to Seek | | | |
|---------------------|------------|--------------------|--------------|-------------|--------------|
| | | 1 High | 2 Moderate | 3 Low | |
| Propensity to Share | 1 Low | 60 31.41 | 101 52.88 | 21 10.99 | 182 95.29 |
| | 2 Moderate | 2 1.05 | 6 3.14 | 1 0.52 | 9 4.71 |
| | | 62 32.46 | 107 56.02 | 22 11.52 | 191 |

Tests

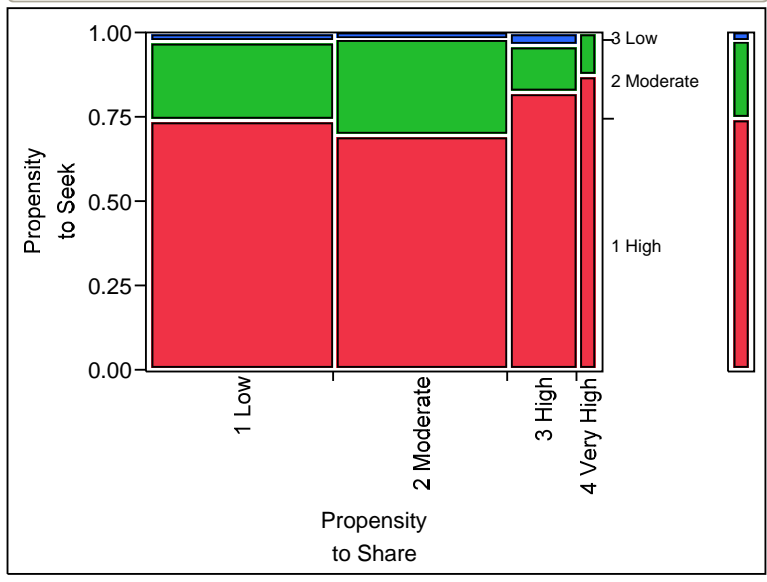
| | N | DF | -LogLike | RSquare (U) |
|------------------|-----------|------------|------------|-------------|
| | 191 | 2 | 0.26170368 | 0.0015 |
| Test | ChiSquare | Prob>ChiSq | | |
| Likelihood Ratio | 0.523 | 0.7697 | | |
| Pearson | 0.497 | 0.7798 | | |

Warning: 20% of cells have expected count less than 5, ChiSquare suspect.

For Hierarchy Organization:

**Contingency Analysis of Propensity to Seek
By Propensity to Share Org Type=Hierarchy**

Mosaic Plot



Contingency Table

| | | Propensity to Seek | | | |
|---------------------|------------|--------------------|------------|-------|-------|
| | | 1 High | 2 Moderate | 3 Low | |
| Propensity to Share | Count | | | | |
| | Total % | | | | |
| | 1 Low | 58 | 18 | 2 | 78 |
| | | 30.85 | 9.57 | 1.06 | 41.49 |
| | 2 Moderate | 51 | 21 | 1 | 73 |
| | 27.13 | 11.17 | 0.53 | 38.83 | |
| 3 High | 24 | 4 | 1 | 29 | |
| | 12.77 | 2.13 | 0.53 | 15.43 | |
| 4 Very High | 7 | 1 | 0 | 8 | |
| | 3.72 | 0.53 | 0.00 | 4.26 | |
| | 140 | 44 | 4 | 188 | |
| | 74.47 | 23.40 | 2.13 | | |

Tests

| | N | DF | -LogLike | RSquare (U) |
|------------------|-----|----|------------------|----------------------|
| | 188 | 6 | 2.0742889 | 0.0172 |
| Test | | | ChiSquare | Prob>ChiSq |
| Likelihood Ratio | | | 4.149 | 0.6566 |
| Pearson | | | 3.785 | 0.7058 |

Warning: 20% of cells have expected count less than 5, ChiSquare suspect.

Future Applications of ELICIT and Conclusions

In this study, we explored how to apply statistical techniques to characterize humans using the ELICIT transaction logs and looked for possible correlations between these characterizations. Overall, members of a hierarchy organization had more variation in their characterizations or settings than members of an edge organization. This result is expected as members of the hierarchy organization have varied roles and privileges while members of the edge organization have the same role and privileges. The team did not observe any significant correlations between the Sharing Modality, Propensity to Seek, and Propensity to Share variables we characterized in these trial runs despite our initial hypothesis.

The results of this analysis are currently being used to inform abELICIT test designs. Our team is heavily engaged in running a series of experiments to verify and validate the agent based software. This work helps ensure that the rule sets for ELICIT agent characteristics are well designed and properly coded. In the near future we hope to duplicate human runs using the agent software. This work supports the development of less costly, more efficient ELICIT experimentation.

The ELICIT software platform is continually undergoing development to increase experimentation capabilities and usability. Experiments can now be set up and conducted using a web based sever and allow for different numbers of subjects and organizational structures. This server provides added convenience, new features, and increased exposure as many experiments are planned for the upcoming months and more are expected to be conducted throughout the course of the year. The ELICIT Community of Interest (CoI) consists of fifty plus members from academia, government, and industry across international cultures, including Canada, Singapore, United Kingdom, Australia, Chile, Germany, Sweden, The Netherlands, Portugal, and the United States. The CoI continues to grow and explore alternative ways of employing the ELICIT experimentation platform. If you wish to join the ELICIT CoI or find out more about ELICIT and related analysis, please visit: <http://www.dodccrp.org/html4/elicit.html>