Module 8:
ELICIT and abELICIT Examples

Network Enabled Command and Control
Short Course

Dr. David S. Alberts
October 2009

Questions Addressed

- What are ELICIT, abELICIT?
- How can these tools help us understand the value and the limitations of different approaches to Focus and Convergence (C2 or Intel)?
- What have been the results to date?

What is ELICIT?

- ELICIT = Experimental Laboratory for Investigating Collaboration, Information-sharing, and Trust
- U.S. DoD (OASD/NII) Command and Control Research Program (CCRP) sponsored the design and development of the ELICIT platform for experimentation focused on information, cognitive, and social domain phenomena
- Purpose of ELICIT-related Experimentation and Analysis is to investigate the cognitive and social impacts of C2 approach and organizational structure (e.g. information sharing, trust, shared awareness, and task performance)
- Initial applications focus on a comparison of traditional hierarchical and edge C2 approaches

ELICIT Scenario

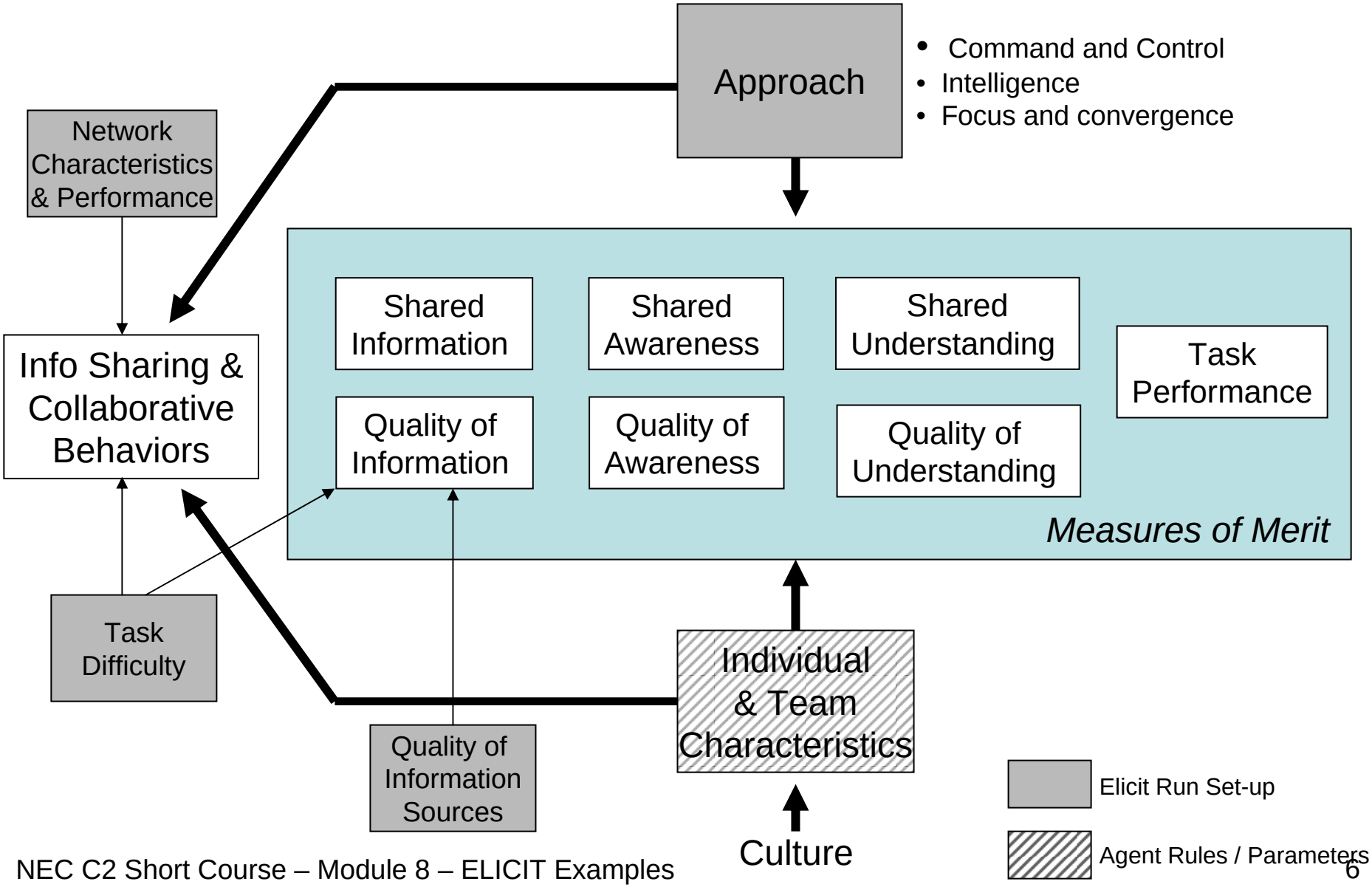
- The goal of each set of participants is to build situational awareness and identify the who, what, when, and where of a pending attack
  - Participants can share factoids directly with each other or post factoids to websites
  - Participants build awareness by gathering and analyzing factoids and interacting with one another
- Participants receive factoids about a future attack
  - Factoids fall into four task categories: who, what, when, and where
  - Factoids are periodically distributed to the participants
  - No one is given sufficient information to solve their assigned problem without receiving information from others
- The receiving, sharing, and posting of factoids and the nature of the interactions between and among participants can be constrained

ELICIT Applications

- ELICIT has been used by researchers to investigate the cognitive and social impacts of C2 approaches and organizational structures (e.g., information sharing, trust, shared awareness, and task performance)

- ELICIT has been used by educators to facilitate discussion of command and control concepts, approaches, and processes (e.g., alternative structures, information flows, and distributions of information)

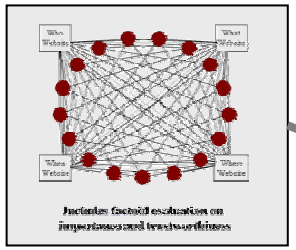
Experimenting with ELICIT

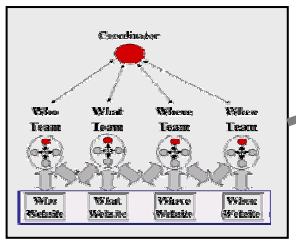


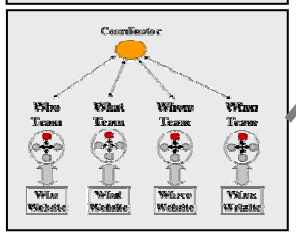
Illustrative Topics that can be Explored

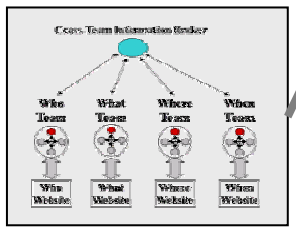
- Information Infrastructure
  - How much networking and communications capabilities are needed to adequately support different approaches (levels of maturity) ?
- Information Sources
  - What is the impact of incorrect and/or incomplete information on task performance as a function of approach?
- Approach
  - Do more mature approaches correspond to better task performance?
  - Which approaches are better able to cope with damage or degradation?
  - Does task difficulty affect task performance as a function of approach?

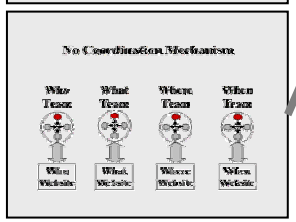
C2 Approach Related Experiments











- C2 Approach
  - Decision Rights Allocation
  - Patterns of Interaction
  - Information Distribution
- Network Characteristics
- Task Difficulty
- Info Sharing and Collaboration
  - Influenced by instructions
  - Knowledge Sharing on higher maturity levels

Affects

Information Position, Shared Information, Information Sharing, Quality of Awareness, Quality of Shared Awareness, Task Performance, Agility

Exploring Relationships

- What is the relationship between
  - average individual propensity to share and shared information?
  - shared information and shared awareness?
  - shared awareness and task performance?
  - team hardness and shared information?
  - average cognitive ability and task performance?
  - explicit leadership and speed of identification?
  - speed of identification and correctness of identification?
  - task difficultly and shared information?
  - willingness to go beyond assigned role or responsibility and information sharing?
  - perceived quality of information and information sharing behaviors?

Results from ELICIT Experiments

- A rich set of data has been generated using the ELICIT experimentation platform with human participants
- Given the growing interest in ELICIT, we expect this experimental data to continue to accumulate
- An agent-based capability has recently been developed, tested, and used to explore archetypical organizational forms
- The results from human and agent runs have yield comparable results

Human Experimental Runs Included in Illustrative Results

- 26 data sets
  - Boston University – 2 runs
  - Naval Postgraduate School – 16 runs
  - US Military Academy – 2 runs
  - Portugal – 6 runs
- 13 of each C2 approach
- 2 civilian groups and 24 military groups
- 7 undergraduate groups and 19 professional groups
- 20 US and 6 Non-US

Extracting Data from ELICIT

- ELICIT generates output in a number of forms
  - Participant survey responses and "scratch paper"
  - Transaction logs recording all information exchange and identify actions
- While rich in data, transaction logs must be processed in order to be formulated for analysis
  - Transactions of each type must be extracted and tabulated
  - Identify attempts must be graded for correctness
- Transactions were parsed and organized into ten-minute intervals to enable observation of how behaviors change over time, and of the timing of identifies
  - Whole-trial statistics were also taken to characterize trials, but difficult to compare due to differences in trial duration

Illustrative Statistical Comparisons

- Non-military v. Military
  - Non-Military: Boston University
  - Military: U.S. Military Academy
- Comparisons between national cultures
  - US participant groups v. Portuguese participant groups
- Undergraduates v. others
  - Undergraduates: U.S. Military Academy
  - Graduates: NPS
- Hierarchy v. edge
- Performance with different factoid sets

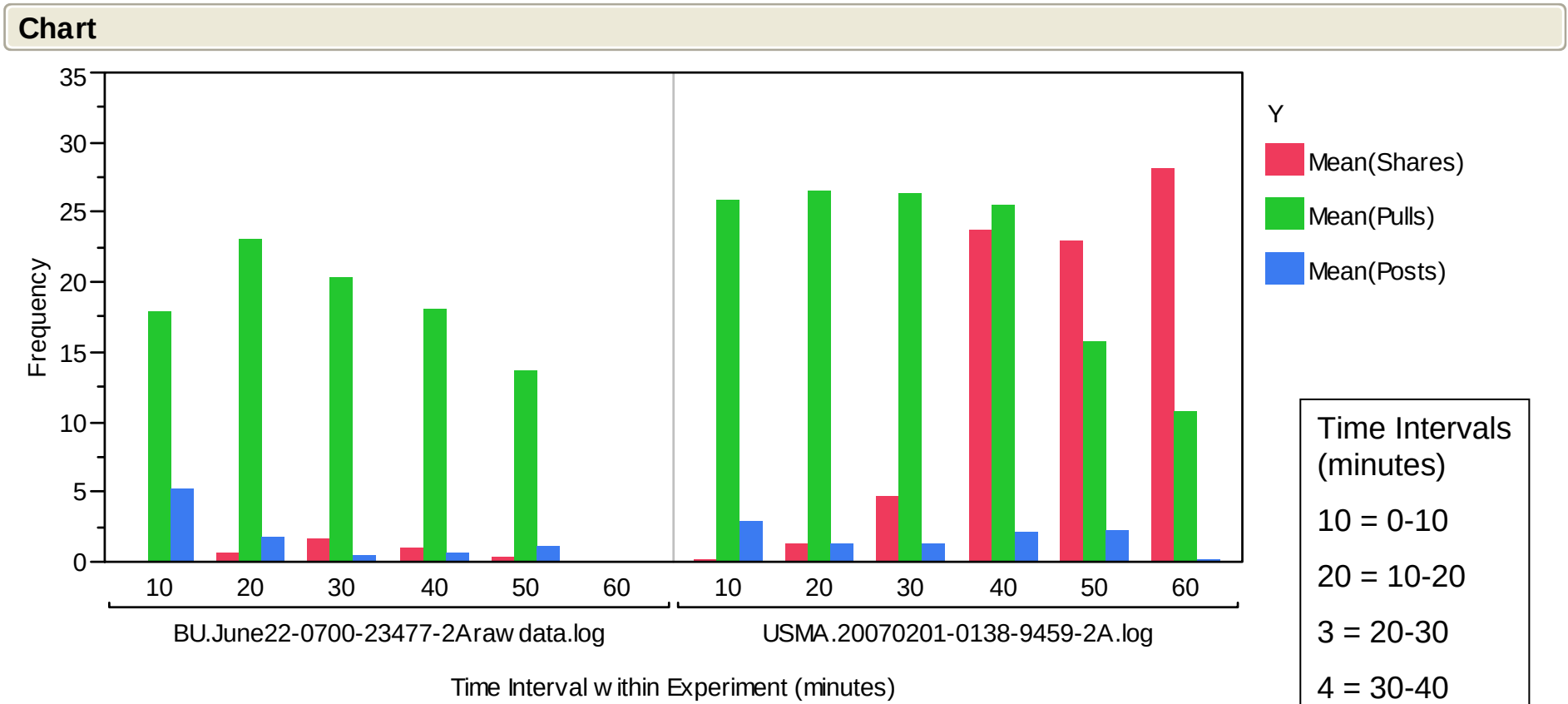
Information Dissemination Metrics

Rate	•Posts + Shares over time •Shares over time •Posts over time
Extent of sharing	Number of unique sharing partners (out-degree)
What is being shared	Portion of known facts shared via •Posts + shares •Shares •Web posts
Receiving rate	Shares-with over time
Receiving extent	Number of unique participants sharing with (in-degree)
Methods used	Portion of known facts received from •Posts + shares •Shares •Web posts

Shares, Pulls, Posts (Edge)

(Non-military vs. Military)

Non-Military Military



Time Intervals (minutes)

10 = 0-10

20 = 10-20

3 = 20-30

4 = 30-40

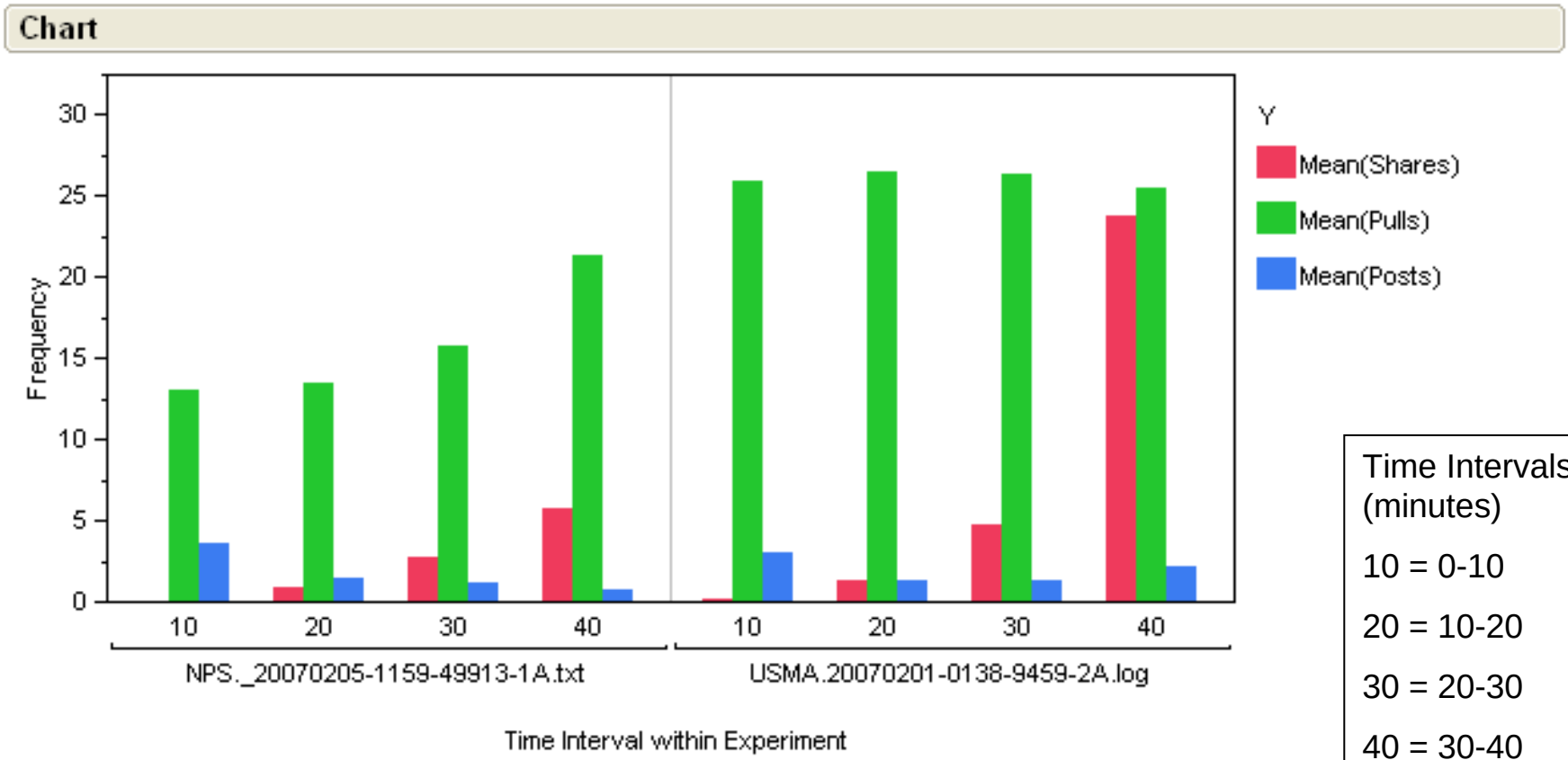
5 = 40-50

6 = 50-60

Shares, Pulls, Posts (Edge)

(Undergraduate vs. Graduate)

Graduates | Undergraduate Students



Time Intervals (minutes)

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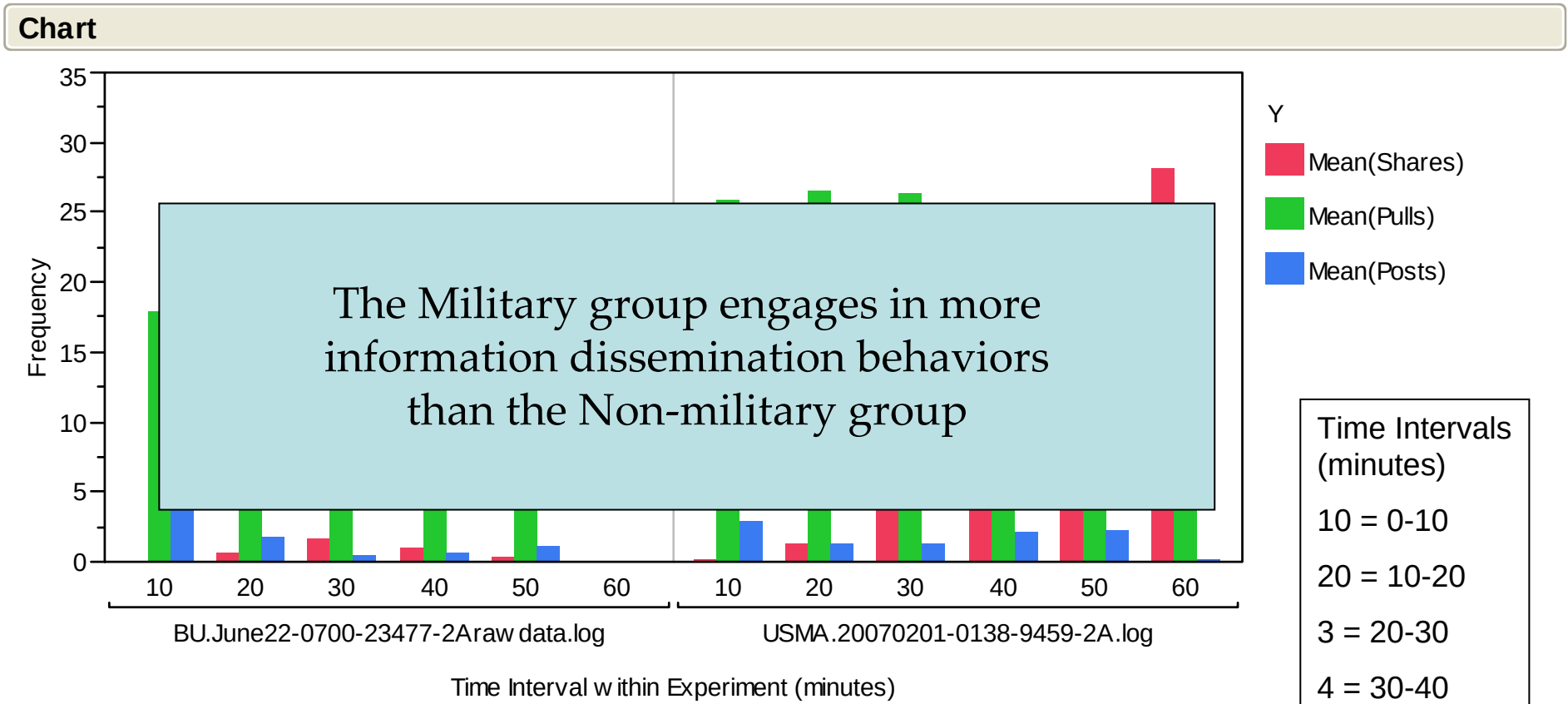
Shares, Pulls, Posts (Edge)

(Non-military vs. Military)

Non-Military Military

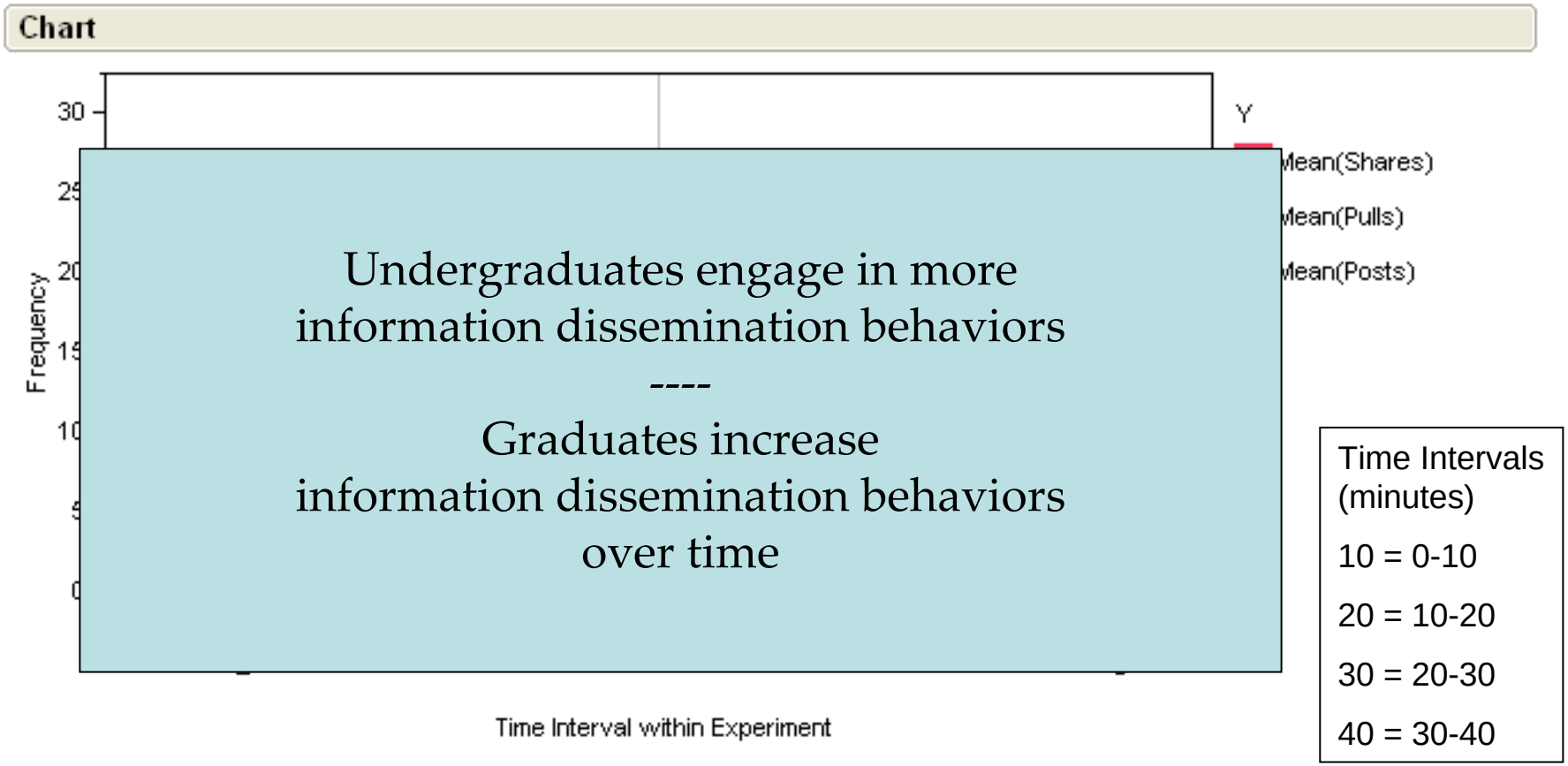


The Military group engages in more information dissemination behaviors than the Non-military group

Shares, Pulls, Posts (Edge)

(Undergraduate vs. Graduate)

Graduates | Undergraduate Students



Undergraduates engage in more information dissemination behaviors

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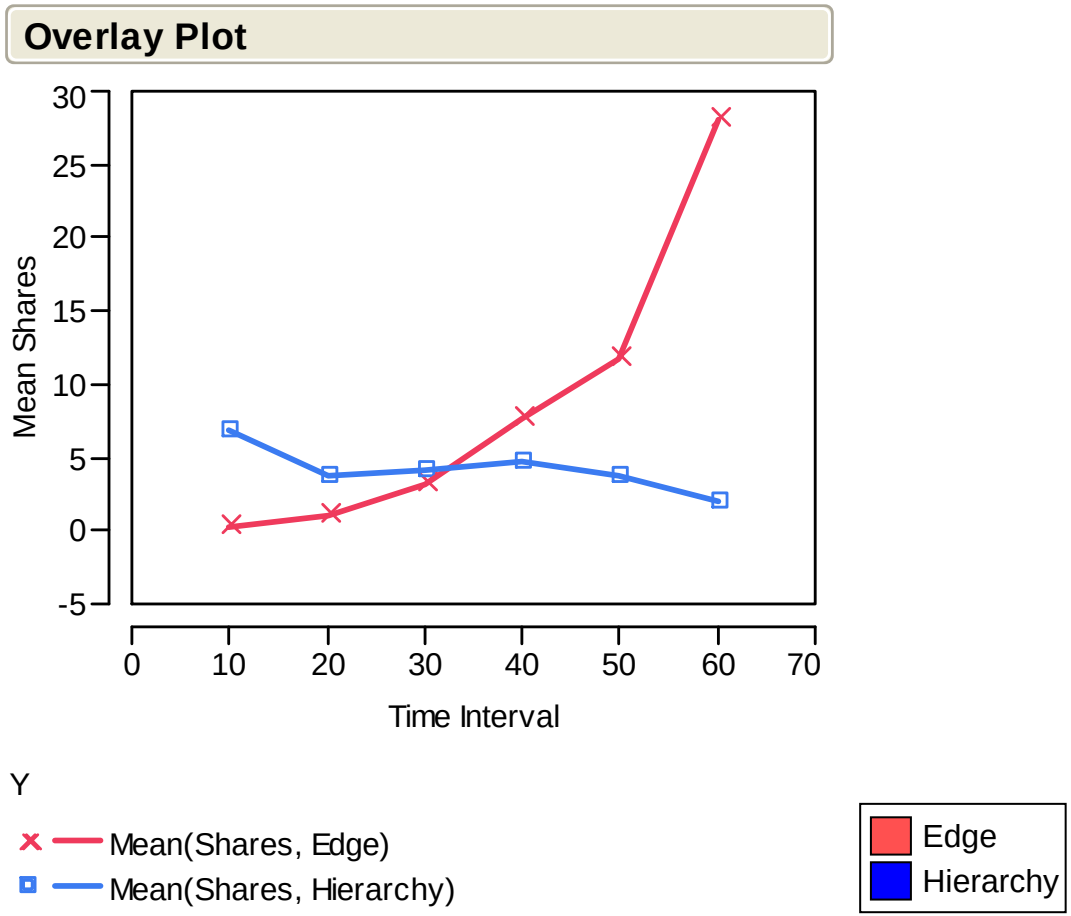
Graduates increase information dissemination behaviors over time

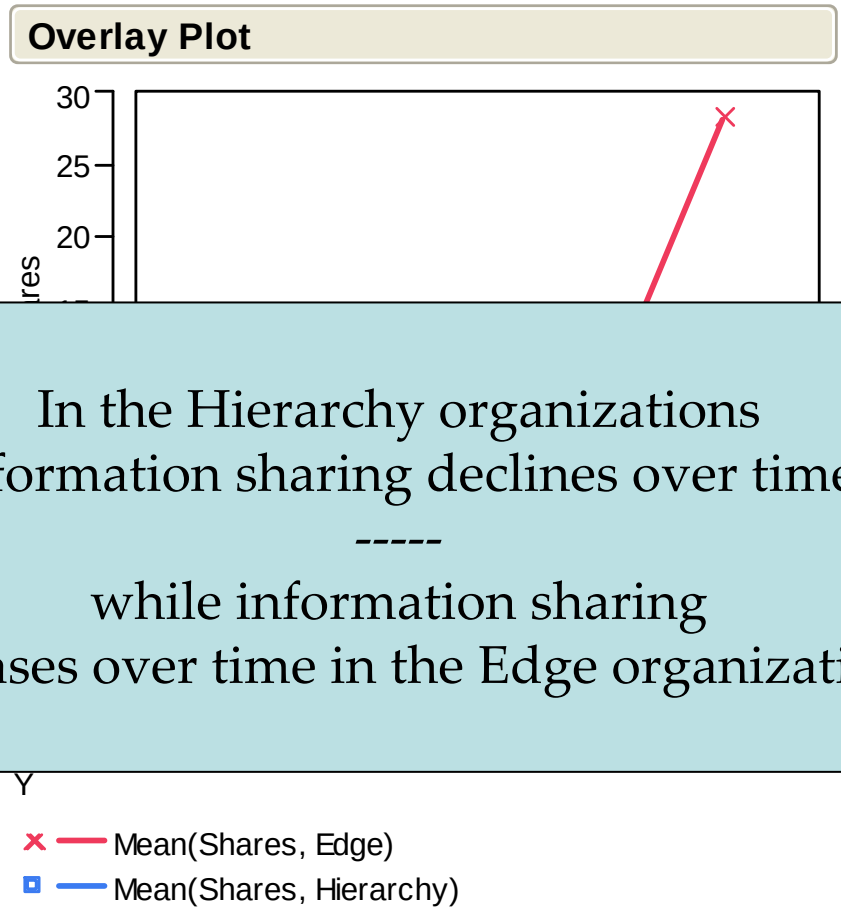
Peer-to-peer Sharing by Time Interval

(Hierarchy vs. Edge)



Peer-to-peer Sharing by Time Interval

(Hierarchy vs. Edge)



In the Hierarchy organizations
information sharing declines over time
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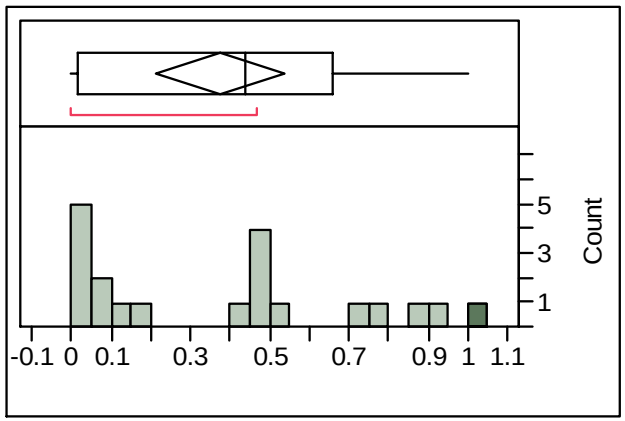
while information sharing
increases over time in the Edge organizations

Correctness

Fraction of Participants with Correct IDs

Edge

Fraction of Participants with Correct ID



Quantiles

100.0%	maximum	1.0000
99.5%		1.0000
97.5%		1.0000
90.0%		0.9353
75.0%	quartile	0.6618
50.0%	median	0.4412
25.0%	quartile	0.0147
10.0%		0.0000
2.5%		0.0000
0.5%		0.0000
0.0%	minimum	0.0000

Moments

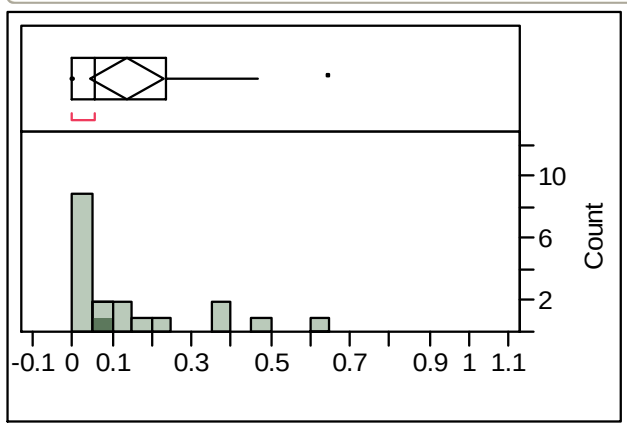
Mean	0.3764706
Std Dev	0.3479524
Std Err Mean	0.0778045
upper 95% Mean	0.5393173
low er 95% Mean	0.2136239
N	20

Agent Trial

Human Trial

Hierarchy

Fraction of Participants with Correct ID



Quantiles

100.0%	maximum	0.64706
99.5%		0.64706
97.5%		0.64706
90.0%		0.47059
75.0%	quartile	0.23529
50.0%	median	0.05882
25.0%	quartile	0.00000
10.0%		0.00000
2.5%		0.00000
0.5%		0.00000
0.0%	minimum	0.00000

Moments

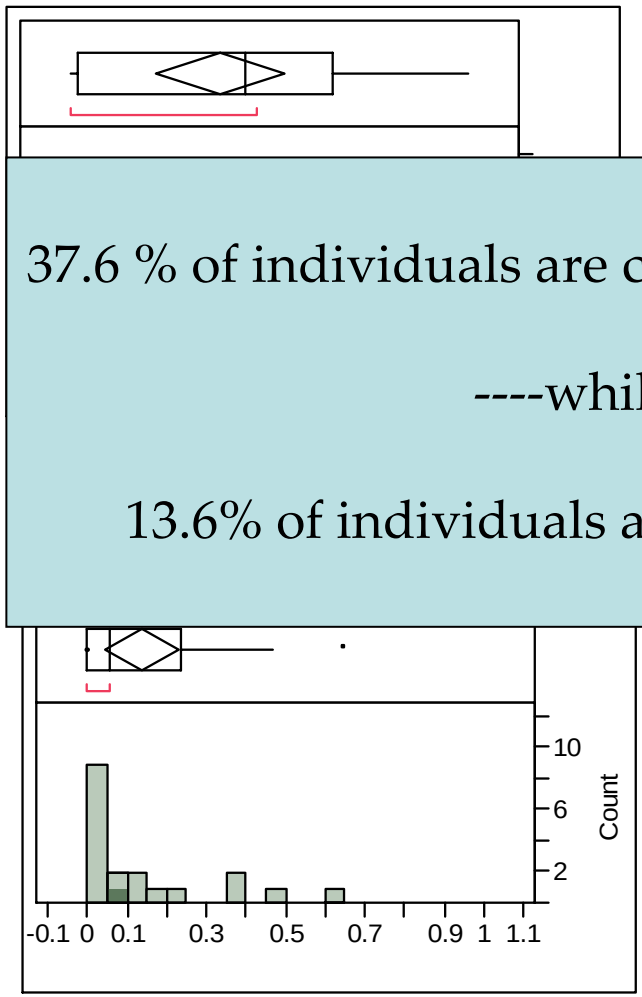
Mean	0.1362229
Std Dev	0.1911665
Std Err Mean	0.0438566
upper 95% Mean	0.2283622
low er 95% Mean	0.0440836
N	19

Correctness

Fraction of Participants with Correct IDs

Edge

Fraction of Participants with Correct ID



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upper 95% Mean	0.2283622
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N	19

Agent Trial

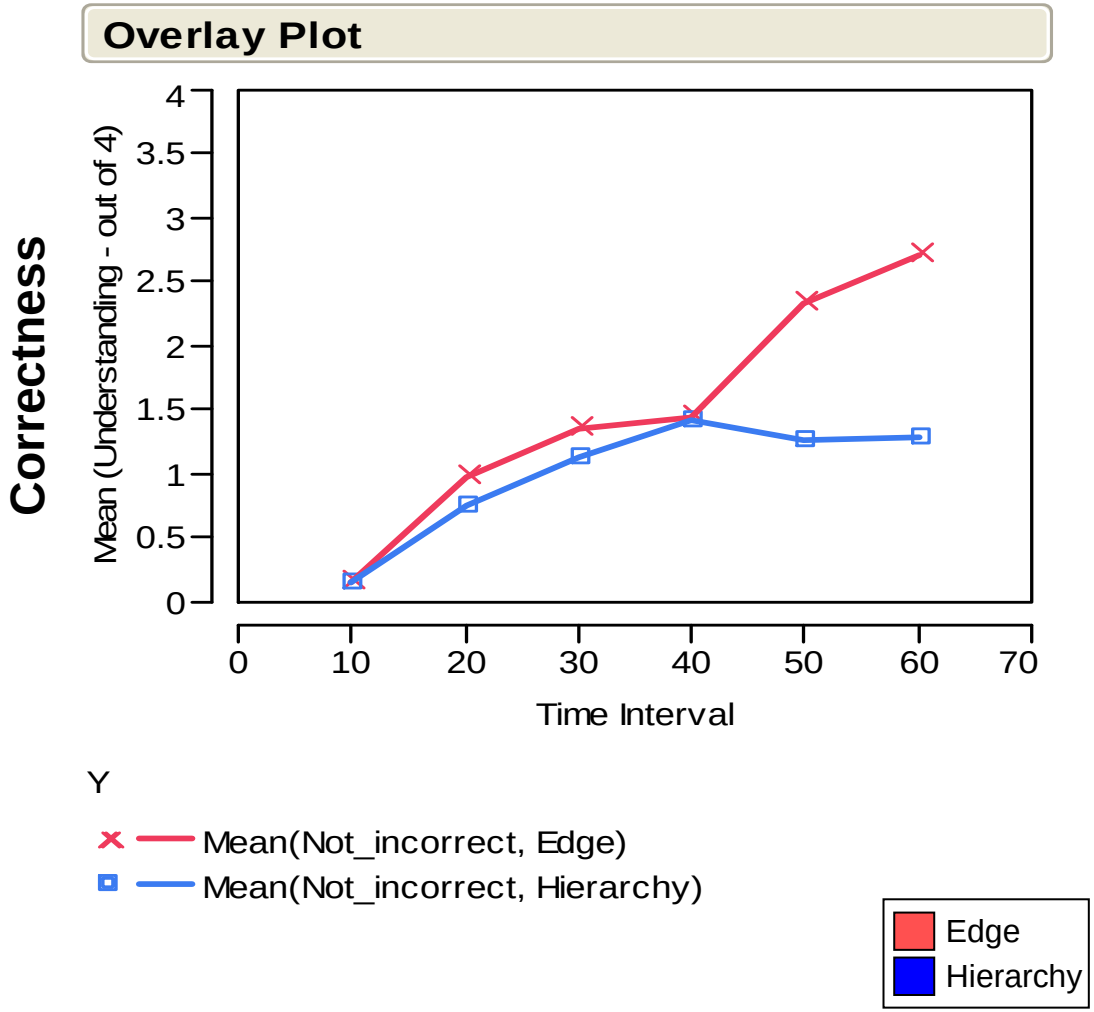
Human Trial

37.6 % of individuals are correct in Edge organizations

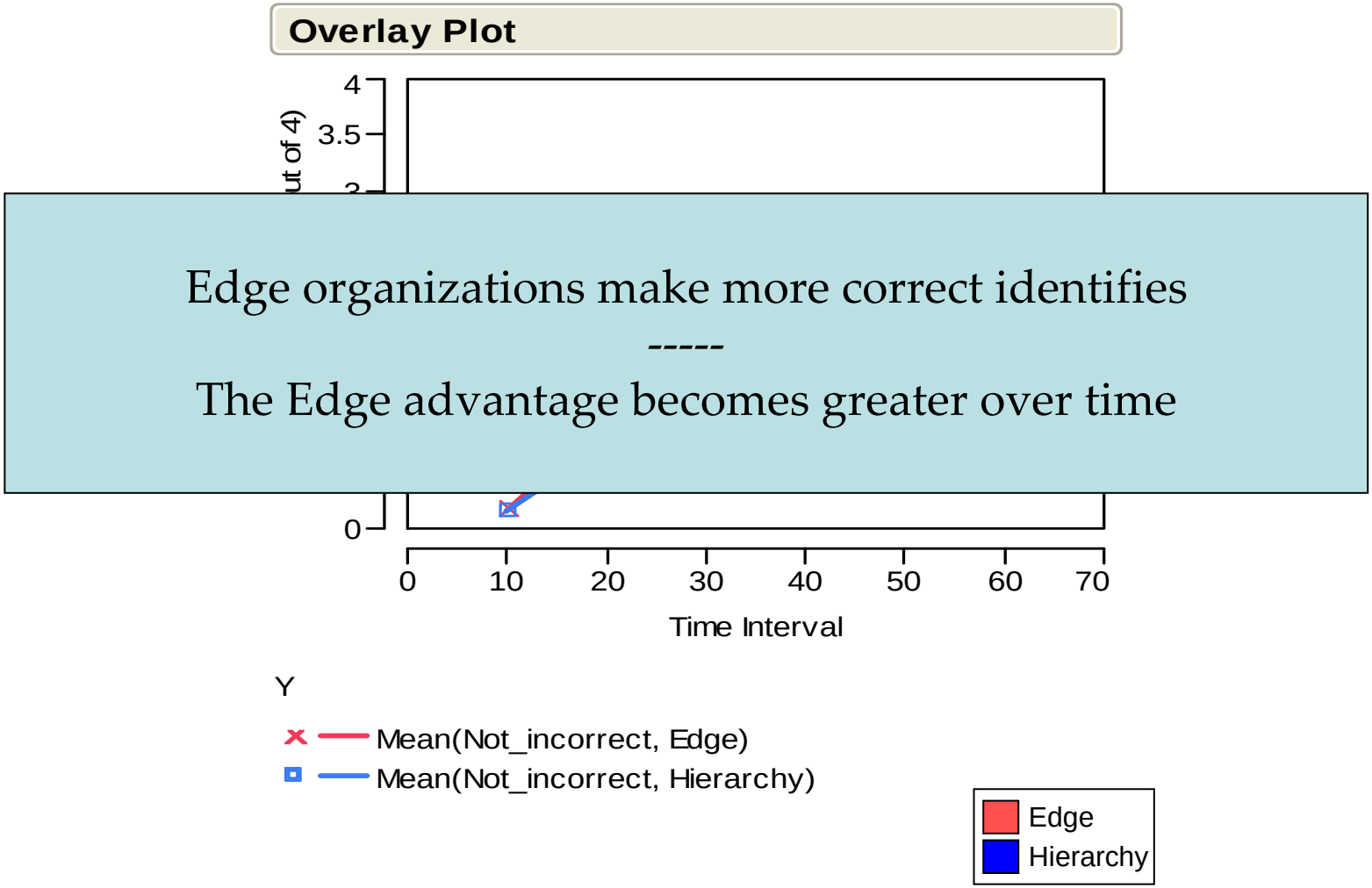
----while only----

13.6% of individuals are correct in Hierarchies

Correctness over Time



Correctness over Time



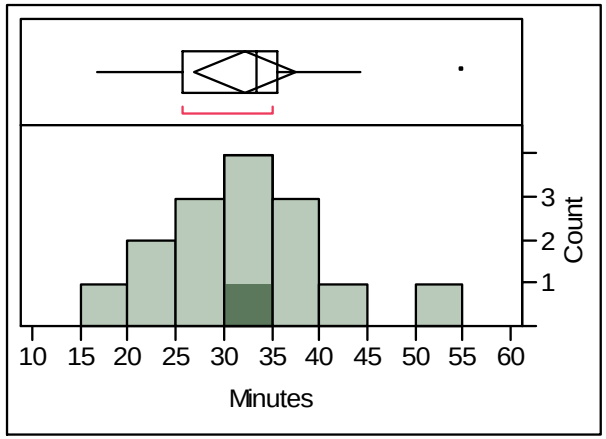
Edge organizations make more correct identifies

The Edge advantage becomes greater over time

Mean Time to Correct ID

Edge

Mean (Time to Correct ID) by Trial



Quantiles

100.0%	maximum	54.817
99.5%		54.817
97.5%		54.817
90.0%		48.471
75.0%	quartile	35.583
50.0%	median	33.364
25.0%	quartile	25.758
10.0%		19.635
2.5%		16.843
0.5%		16.843
0.0%	minimum	16.843

Moments

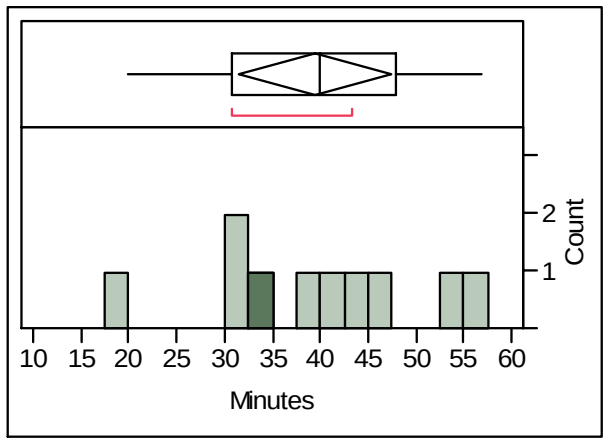
Mean	32.277561
Std Dev	9.5474423
Std Err Mean	2.465139
upper 95% Mean	37.564759
low er 95% Mean	26.990364
N	15

Agent Trial

Human Trial

Hierarchy

Mean (Time to Correct ID) by Trial



Quantiles

100.0%	maximum	56.975
99.5%		56.975
97.5%		56.975
90.0%		56.622
75.0%	quartile	47.912
50.0%	median	39.988
25.0%	quartile	30.744
10.0%		20.923
2.5%		19.833
0.5%		19.833
0.0%	minimum	19.833

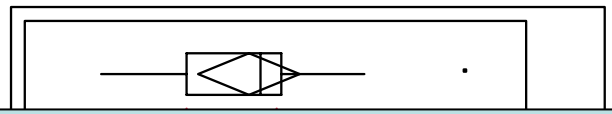
Moments

Mean	39.466389
Std Dev	11.242753
Std Err Mean	3.5552705
upper 95% Mean	47.50897
low er 95% Mean	31.423808
N	10

Mean Time to Correct ID

Edge

Mean (Time to Correct ID) by Trial



Quantiles		
100.0%	maximum	54.817

Moments	
Mean	32.277561

Hierarchies take 22% longer to get the correct answer

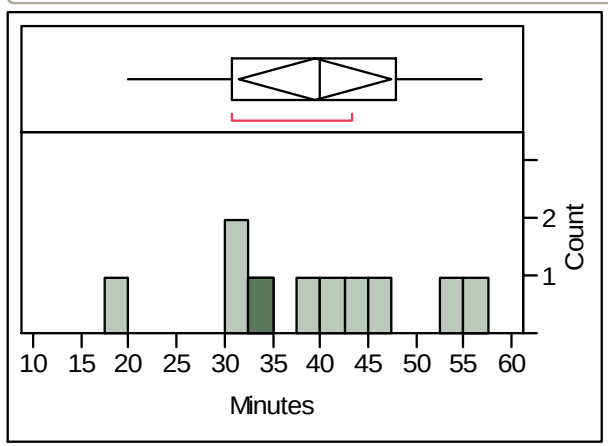
32.3 minutes for Edge organizations

39.5 minutes for Hierarchies

t Trial

an Trial

Mean (Time to Correct ID) by Trial



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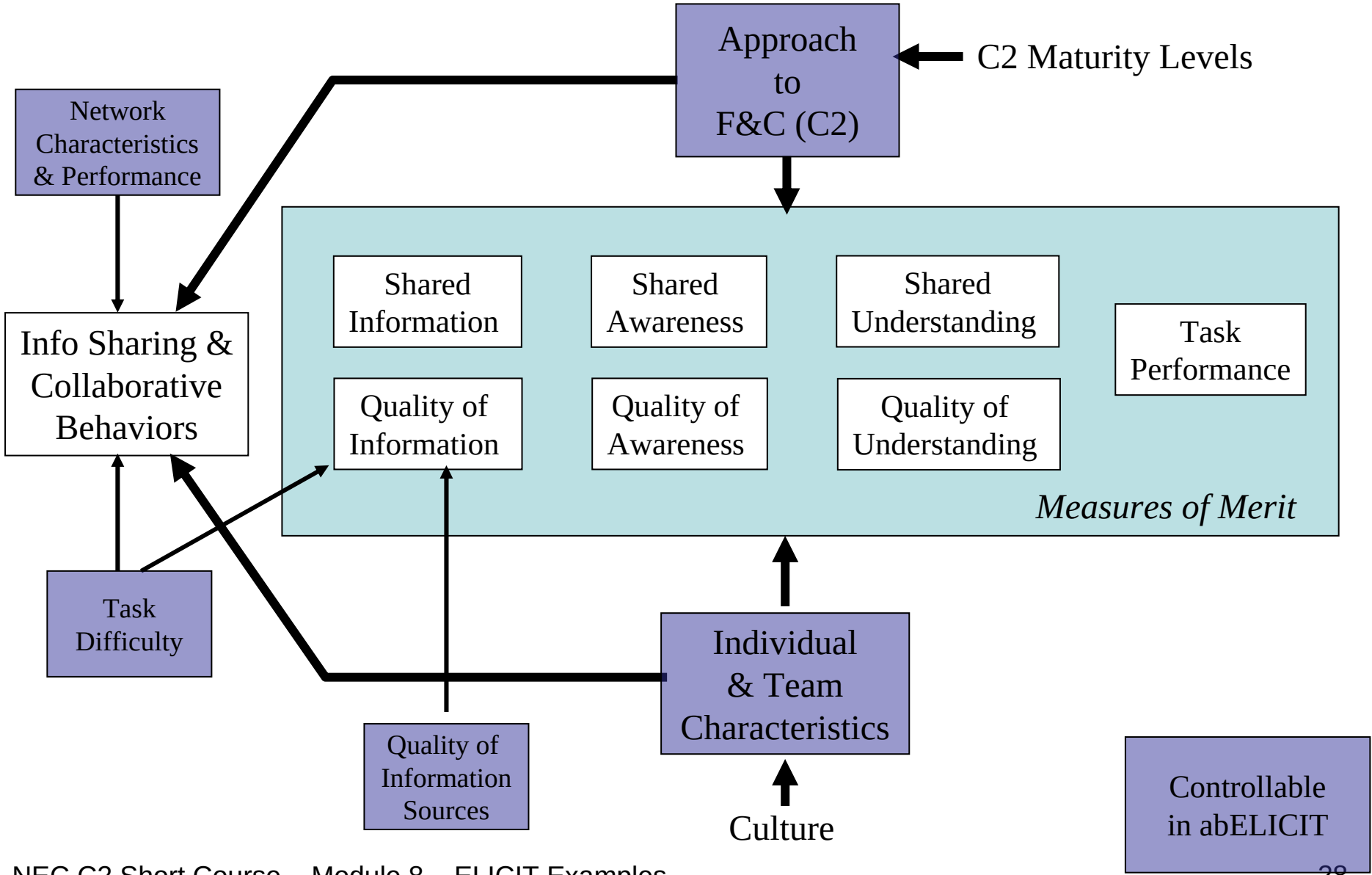
What is abELICIT ?

- ELICIT was developed as a person-in-the-loop experimentation platform
- Experimentation with live groups of individuals is time consuming and expensive
- This limits the number of runs that can be made. This, in turn, limits the exploration of treatment effects
- Therefore, the CCRP decided to develop agents that could be used in the place of people
- abELICIT is an all agent-based simulation model that is built upon the ELICIT experimentation platform

Controllable in abELICIT



abELICIT Run Setups

Organization Structure	Must Share	Must Share Websites	Sharing Modality	Propensity to Share	Propensity to Seek
(1) Industrial Age Hierarchy	**Members:** All team members, team leader **Leader:** All team members, coordinator **Coordinator:** All team leaders		Share Only (Peer to Peer Only)	Low	Moderate
(2) Information Age Hierarchy	**Members:** All team members, team leader **Leader:** All team members, coordinator **Coordinator:** All team leaders	**Members:** team website **Leaders:** team website **Coordinator:** all websites	Both	Low	Moderate
(3) Industrial Age Hierarchy with Coordination	**Members:** All team members, team leader **Leader:** All team members, all team leaders, coordinator **Coordinator:** All team leaders		Share Only (Peer to Peer Only)	Low	Moderate
(4) Information Age Hierarchy with Coordination	**Members:** All team members, team leader **Leader:** All team members, all team leaders, coordinator **Coordinator:** All team leaders	**Members:** team website **Leaders:** all websites **Coordinator:** all websites	Both	Low	Moderate
(5) Perfect Edge			Post Only	High	Moderate

abELICIT Comparison Runs

Organization Structure	Must Share	Must Share Websites	Sharing Modality	Propensity to Share	Propensity to Seek
(1) Industrial Age Hierarchy	**Members:** All team members, team leader **Leader:** All team members, coordinator **Coordinator:** All team leaders		Share Only (Peer to Peer Only)	Low	Moderate
(2) Information Age Hierarchy equates to human Hierarchy runs	**Members:** All team members, team leader **Leader:** All team members, coordinator **Coordinator:** All team leaders	**Members:** team website **Leaders:** team website **Coordinator:** all websites	Both	Low	Moderate
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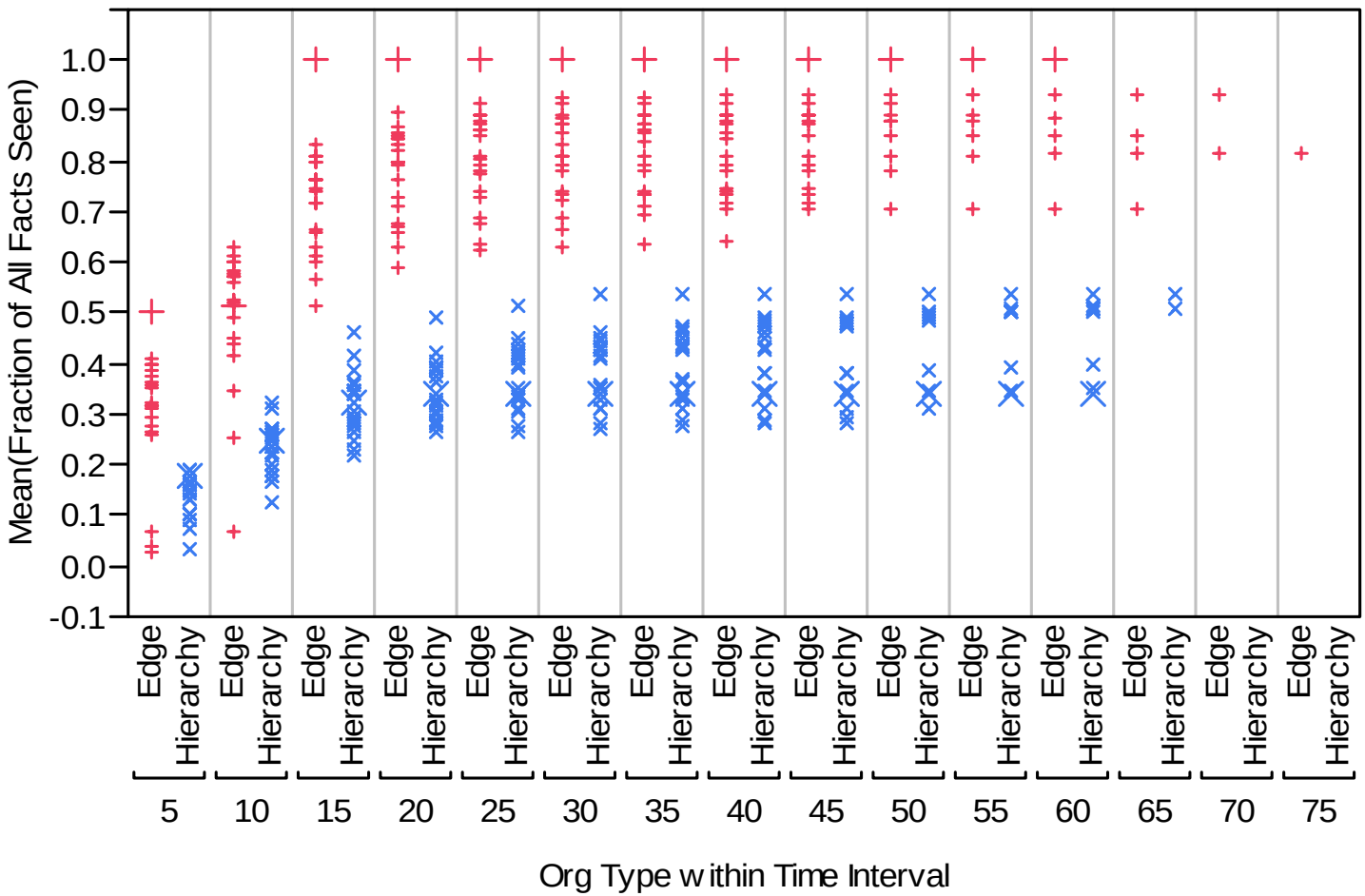
Distribution of Information

The cumulative number of unique facts to which each participant has access over time

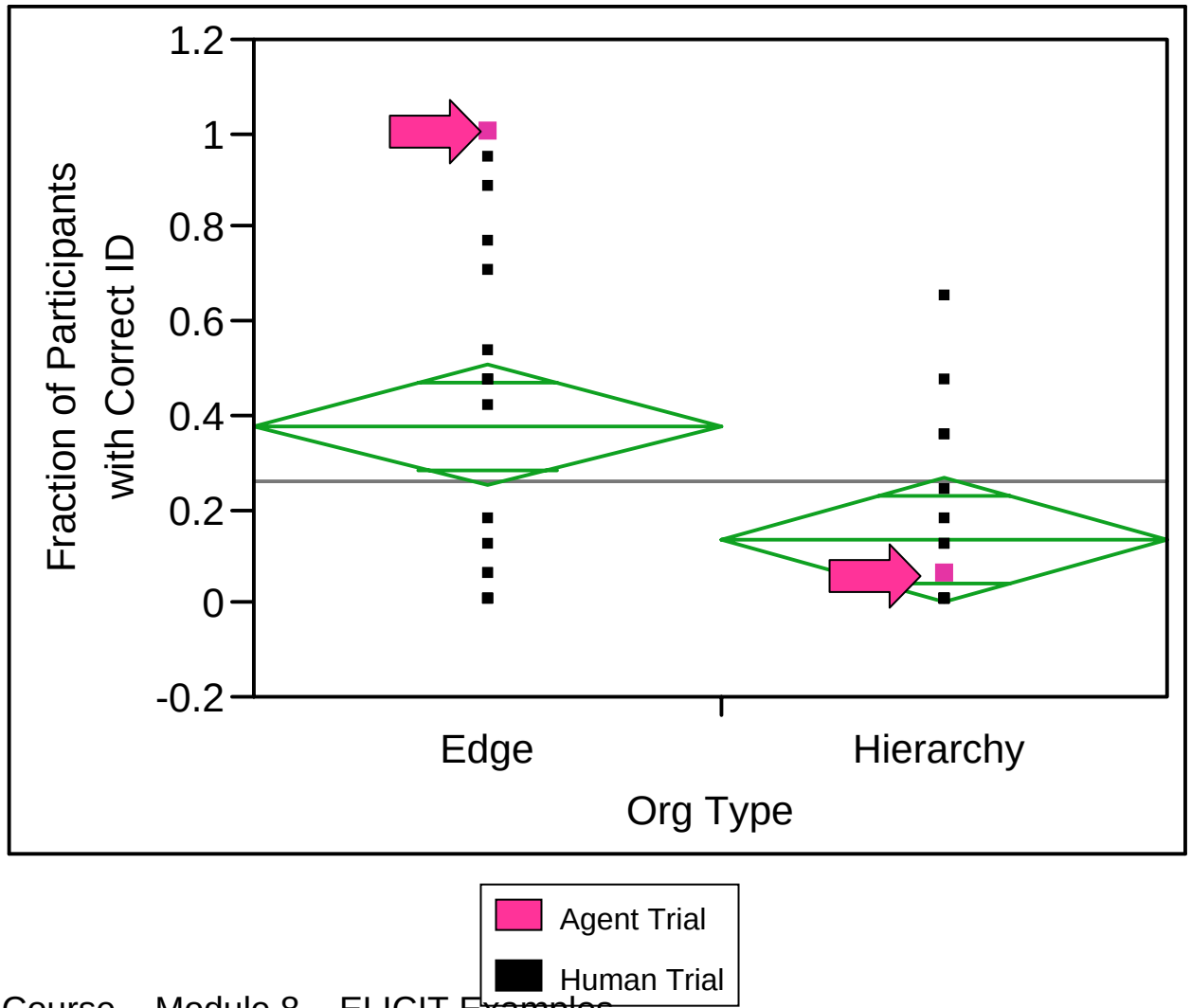


Org Type Edge Hierarchy

*Oversize markers signify Agent Trials

MOE: Correctness

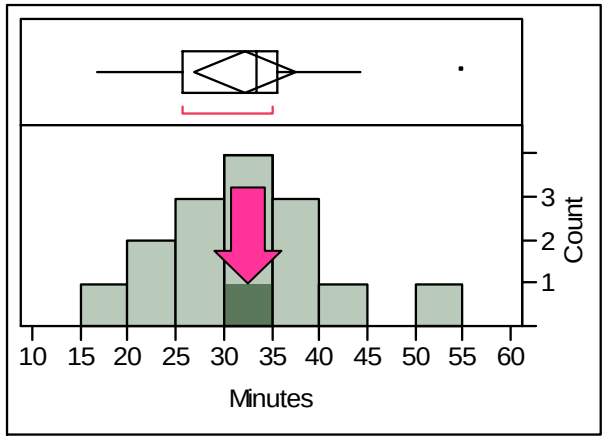
Fraction of Participants with Correct IDs



Mean Time to Correct ID

Edge

Mean (Time to Correct ID) by Trial



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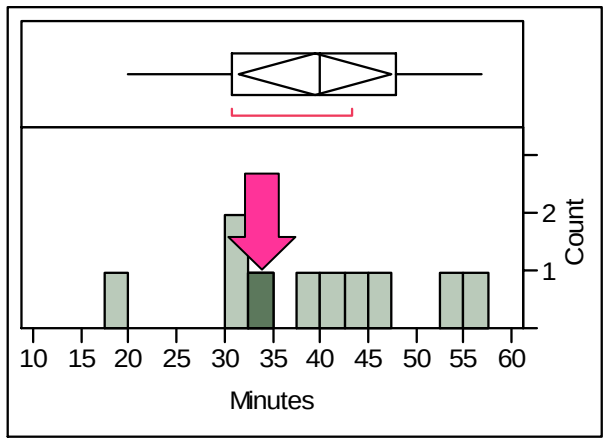

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