Hypothesis Testing of Edge Organizations: Empirically Calibrating an Organizational Model for Experimentation

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Agenda

- Motivation
  - Research Questions
- Points of Departure
  - Previous hypothesis testing
  - POW-ER extensions
  - Cognitive Science: Learning and forgetting rates
- Calibration and Validation
  - AROUSAL Exercise
- Extended agent-based computational model POW-ER
  - ELICIT model
    - Experiments
- C2 Application
- Next Steps
- Theoretical Contributions
Motivation

- Edge Organization definition
  - No headquarters to rely upon
  - Requires: shared awareness / self synchronization

- Knowledge flow is especially critical for Edge Organizations
  - High levels of strategic & operational knowledge needed at nodes
  - Enables “agility” in an uncertain environment
  - Understanding knowledge growth & decay in Edge organizations - critical for optimizing performance
Research Questions

- How can we model and simulate Edge vs. Hierarchy organizational forms engaged in similar project-oriented tasks, taking account of the impacts of individual learning and forgetting on performance outcomes for the two structures?
  - How can individual skill acquisition and decay be computationally modeled, calibrated, and validated?
  - How are Edge vs. Hierarchy organizations and projects effected by the sum of individual participants’ skill growth and decay?
Points of Departure

- **Hypothesis Testing of Edge Organizations**
  - Nissen, 10th ICCRTS, 2005
  - Orr and Nissen, 11th ICCRTS, 2006

- **Cognitive Science**
  - Learning and Forgetting rates
    - Anderson, 2005
    - Sikstrom and Jaber, 2004 and 2002
  - Skill Classification
    - Dar-El et al, 1995
Different skill types seem to have different learning curves

- Ranging from highly cognitive to highly motor skills

Modeling High Cog to High Motor

![Graph showing learning curves for different skill types](image)
Conceptual Model
Individual Skill Acquisition and Decay

- Extensions to POW-ER computational modeling
- Develop fine-grained agent knowledge metric
  - Provide for dynamic, continuous knowledge over time
- Focus on individual knowledge
  - Inflows through OJT
  - Outflows through decay
Empirical Validation of Learning Rates

Dar-El Learning Curves *Plotted Against* Observed Individual & Group Learning Rates
Empirical Validation of Learning Rates
Arousal Exercise

Dar-El Learning Curves *Plotted Against*
Observed Individual & Group Learning Rates

- Skill Completion Time
- Time periods

- Qtr’s 1-3
- Interruption
- Qtr’s 4-7

Legend:
- Hi Cog
- More Cog
- More Motor
- Hi Motor
- Individual
- Group
## Organizational Level POW-ER Models

Empirical findings from AROUSAL learning and forgetting

<table>
<thead>
<tr>
<th>Metric</th>
<th>Empirical Data</th>
<th>POW-ER Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duration (without learning)</td>
<td>609 days</td>
<td></td>
</tr>
<tr>
<td>Duration (with learning)</td>
<td>348 days</td>
<td></td>
</tr>
<tr>
<td>Percent Savings from Learning</td>
<td>42.9%</td>
<td></td>
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</tbody>
</table>
ELICIT Exercise

- Anti-terrorist, intelligence (knowledge) sharing game
- 17 players
- Either Edge or Hierarchy organizations
  - All players may share information with each other
  - Hierarchy is limited to viewing own team’s website
  - No talking
- Each player required to identify target
  - Who, what when, where
- Allowed 60 minutes
ELICIT Exercise

Correct Responses in 10-minute Intervals
For Different Organizational Forms

Correct Answers

Hierarchy (2 game avg)
Edge

10-Minute Intervals (non-cumulative)
Organization Level POW-ER Models

ELICIT Exercise: Edge and Hierarchy
## POW-ER Experimental Results

### 3 Exercise Rounds: 1 Break After 2\textsuperscript{nd} Round

<table>
<thead>
<tr>
<th>Metric</th>
<th>Hierarchy (3 Rounds)</th>
<th>Edge (3 Rounds)</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Mean (Std. deviation)</td>
<td>Mean (Std. deviation)</td>
</tr>
<tr>
<td></td>
<td>No learning</td>
<td>With learning and forgetting</td>
</tr>
<tr>
<td>Duration (days)*</td>
<td>368.2 (22.0)</td>
<td>346.0 (28.5)</td>
</tr>
<tr>
<td>\textbf{6.1% Improvement} &amp; 367.1 (37.0)</td>
<td>\textbf{15.2% Improvement}</td>
<td></td>
</tr>
<tr>
<td>Coordination (days)*</td>
<td>730.4 (23.9)</td>
<td>764.0 (27.0)</td>
</tr>
<tr>
<td>Rework (days)</td>
<td>865.7 (49.2)</td>
<td>870.8 (58.4)</td>
</tr>
<tr>
<td>Functional Exception Work (days)</td>
<td>1471.1 (848.2)</td>
<td>1477.1 (841.2)</td>
</tr>
<tr>
<td>Total Work (days)</td>
<td>3688.2 (90.2)</td>
<td>3718.7 (109.1)</td>
</tr>
<tr>
<td>Functional Risk*</td>
<td>.412 (.015)</td>
<td>.411 (.017)</td>
</tr>
<tr>
<td>Process Quality Risk*</td>
<td>.293 (.008)</td>
<td>.291 (.008)</td>
</tr>
<tr>
<td>Cost ($K)*</td>
<td>1997.1 (47.2)</td>
<td>1616.1 (89.2)</td>
</tr>
</tbody>
</table>
C2 Application

- Example: Crew training (deployment preparation)
  - Consider improvement in command’s performance through adoption of edge-like organizational qualities
- Leverage experimental results to develop and test new command models
  - To predict project lengths for a single project
  - To consider impacts of other agent-based knowledge interventions
    - e.g., training and mentoring
Next Steps

- Develop and validate further using latest ELICIT data, so that we can
  - Improve our predictions of project lengths for a single project
  - Model the effects of other knowledge interventions
    - Training, mentoring
    - Obsolescence, interference
Theoretical Contributions

- Quantitative analysis of how micro behaviors (learning and forgetting) affect organizational performance, extending our understanding of organizational learning

- Validated and calibrated tool to develop and test individual knowledge flow impacts on Edge and other organizational forms
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