



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

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<http://crgp.stanford.edu>



Acknowledgements: OASD-NII/CCRP and Center for Edge Power



Agenda

- Motivation
- Research Questions
- Points of Departure
 - ▶ Previous hypothesis testing
 - ▶ Cognitive Science: Learning and forgetting rates
- Conceptual Model
 - ▶ POW-ER 3.2 extensions
- Calibration
 - ▶ AROUSAL Exercise
- Validation
 - ▶ ELICIT Exercise
 - Edge vs. Hierarchy
- C2 Application
- Theoretical Contributions
- Next Steps



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

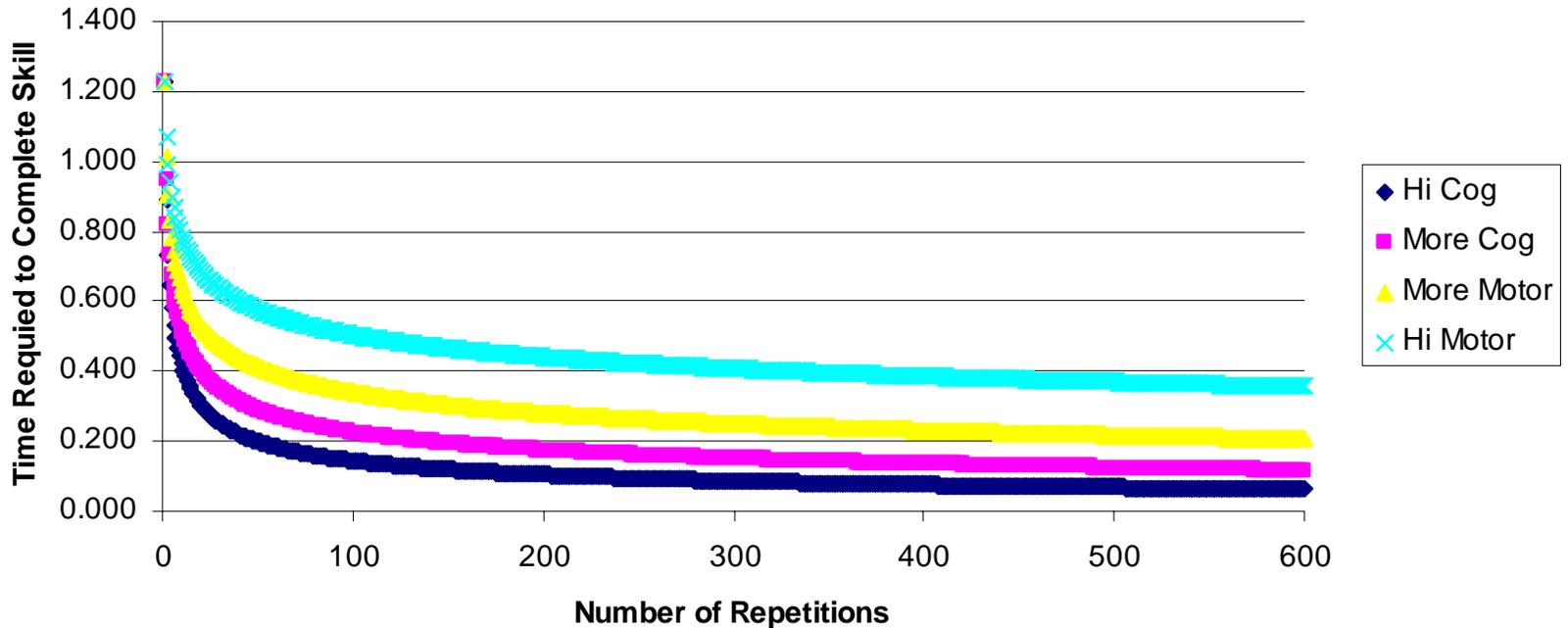


Theoretical Point of Departure

Skill Context (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

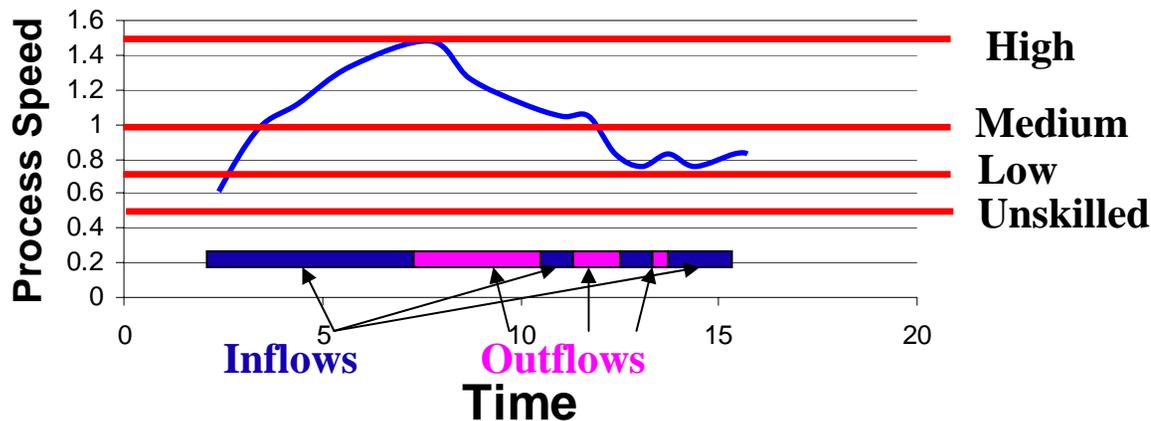




Conceptual Model

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



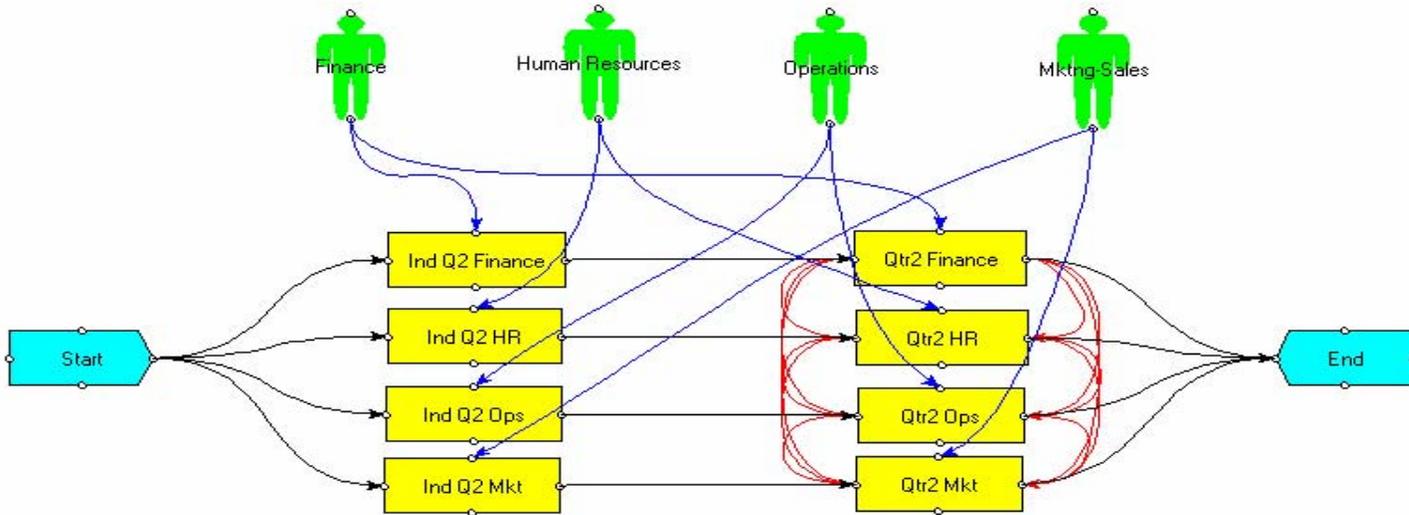


AROUSAL Model

POW-ER 3.2

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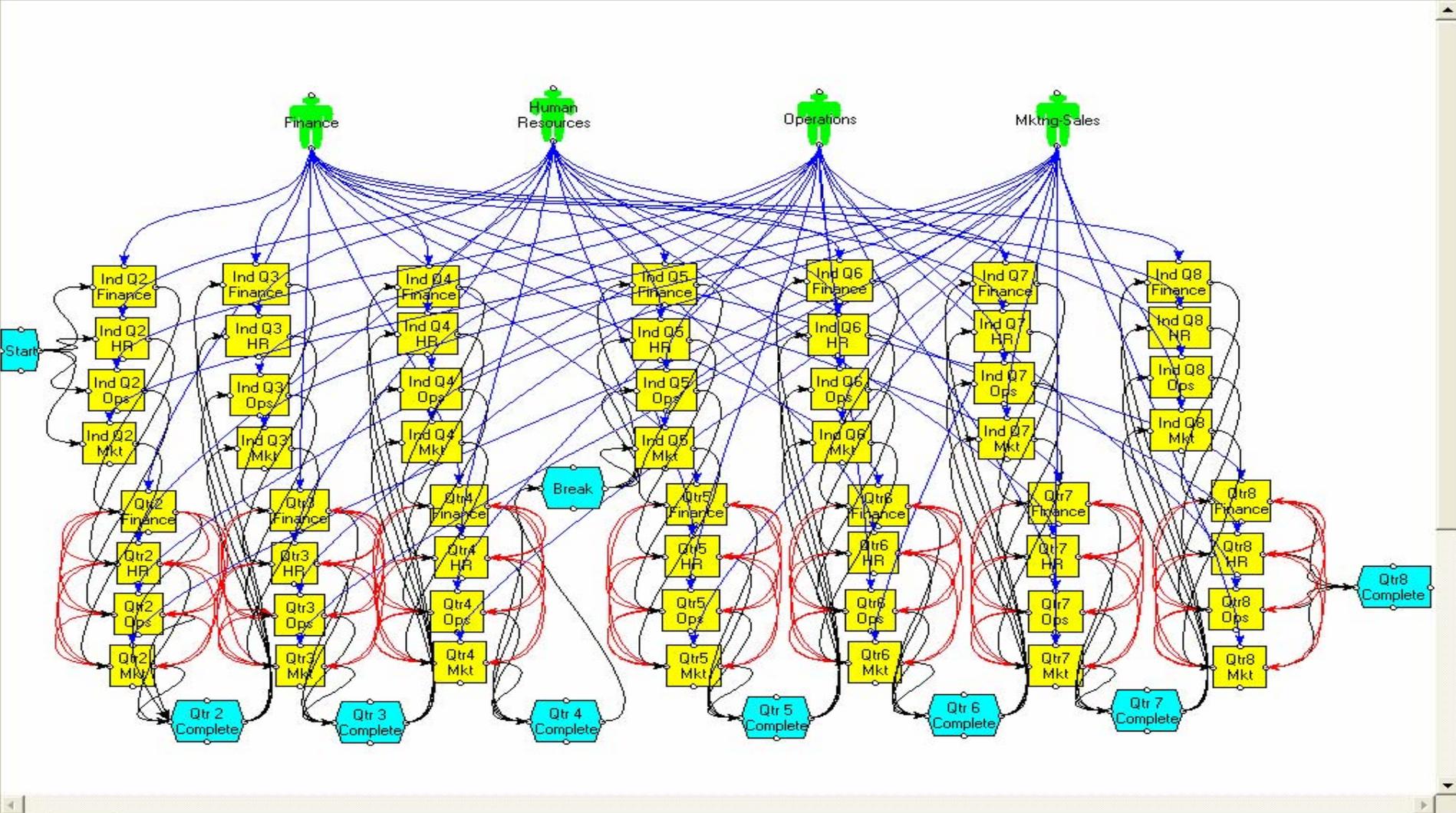


AROUSAL Model

POW-ER 3.2

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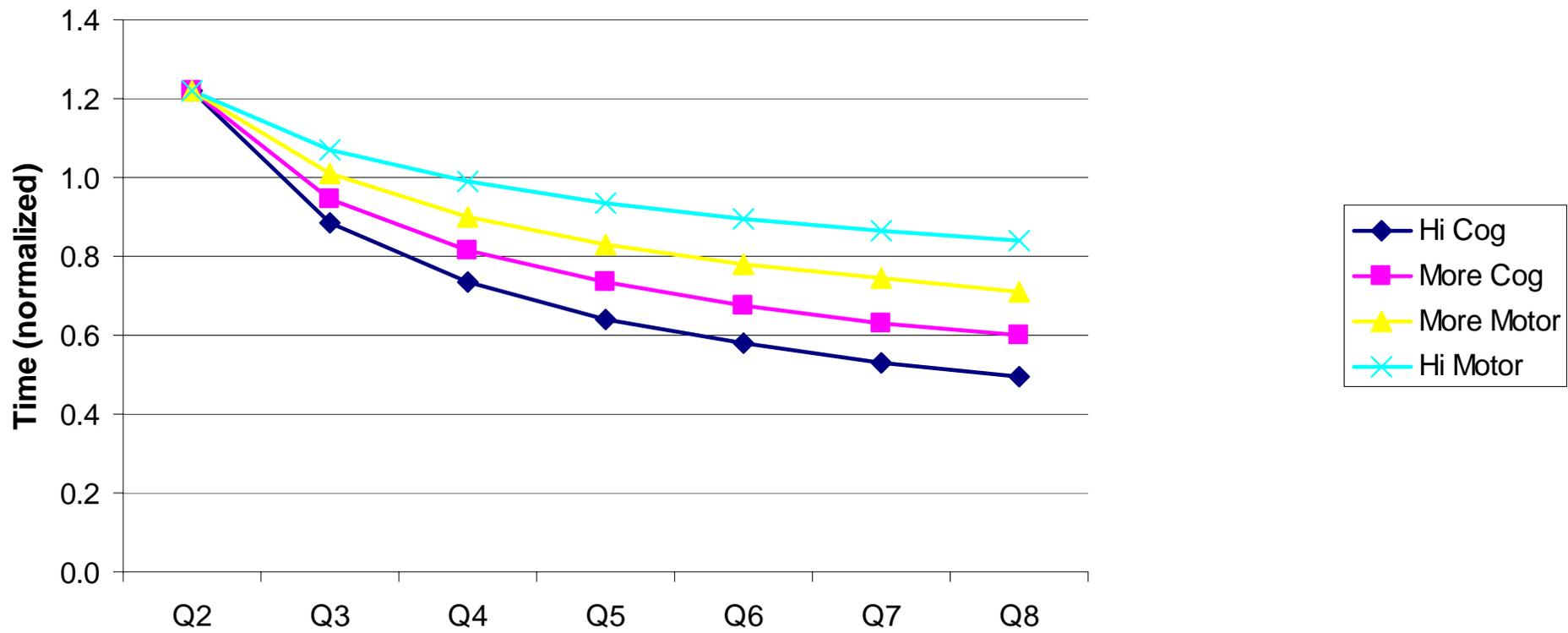




Empirical Validation of Learning Rates

Arousal Exercise

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

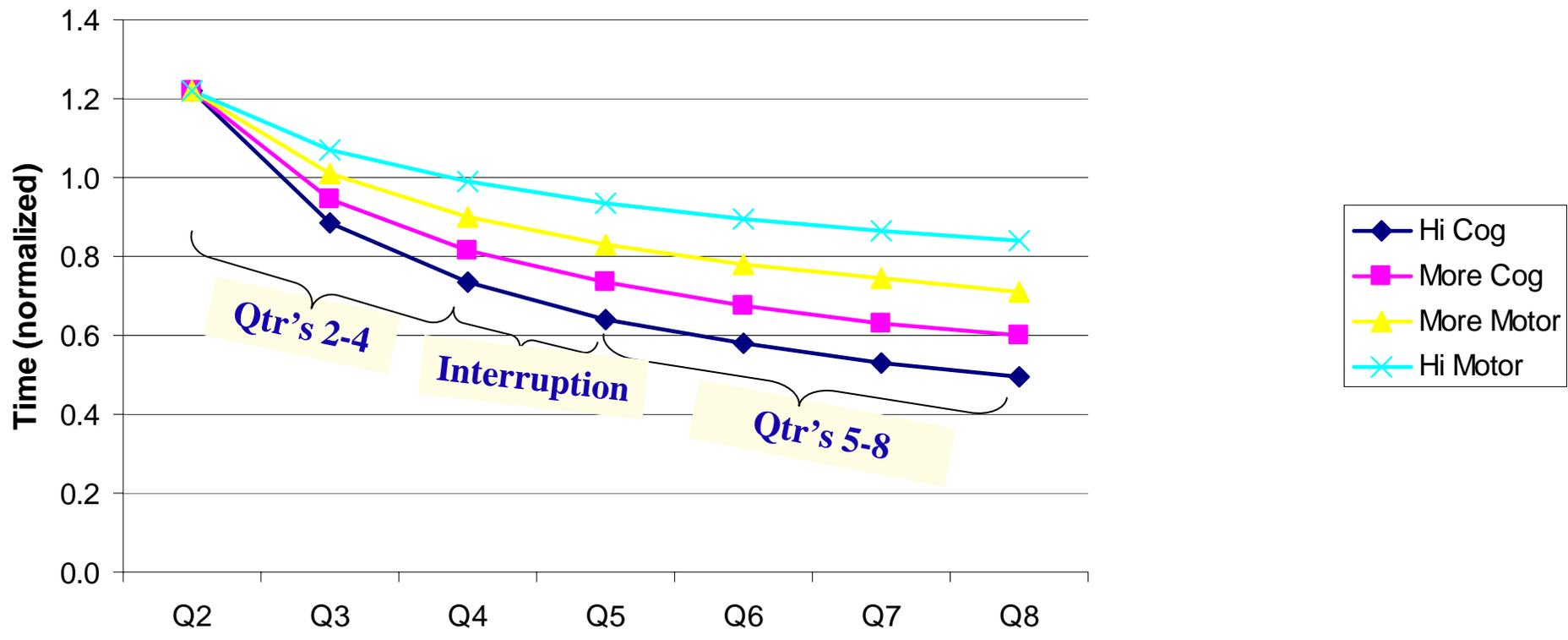




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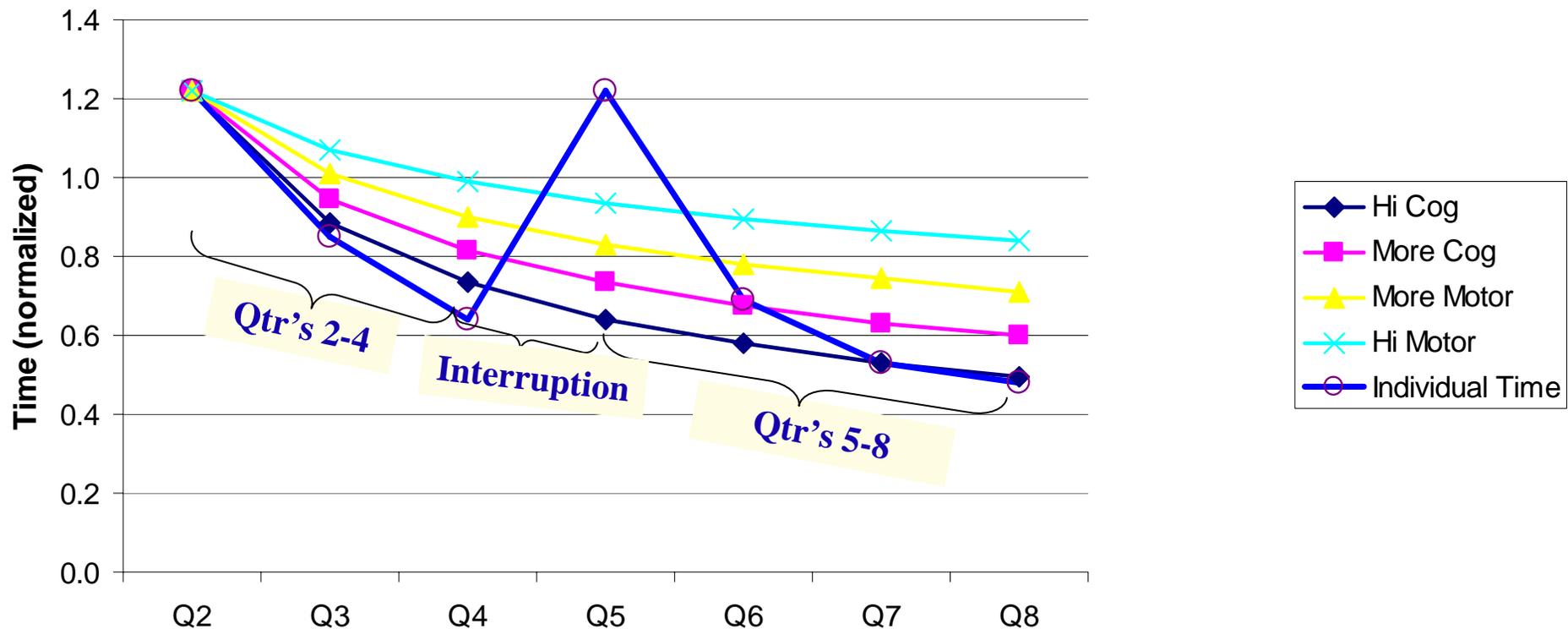




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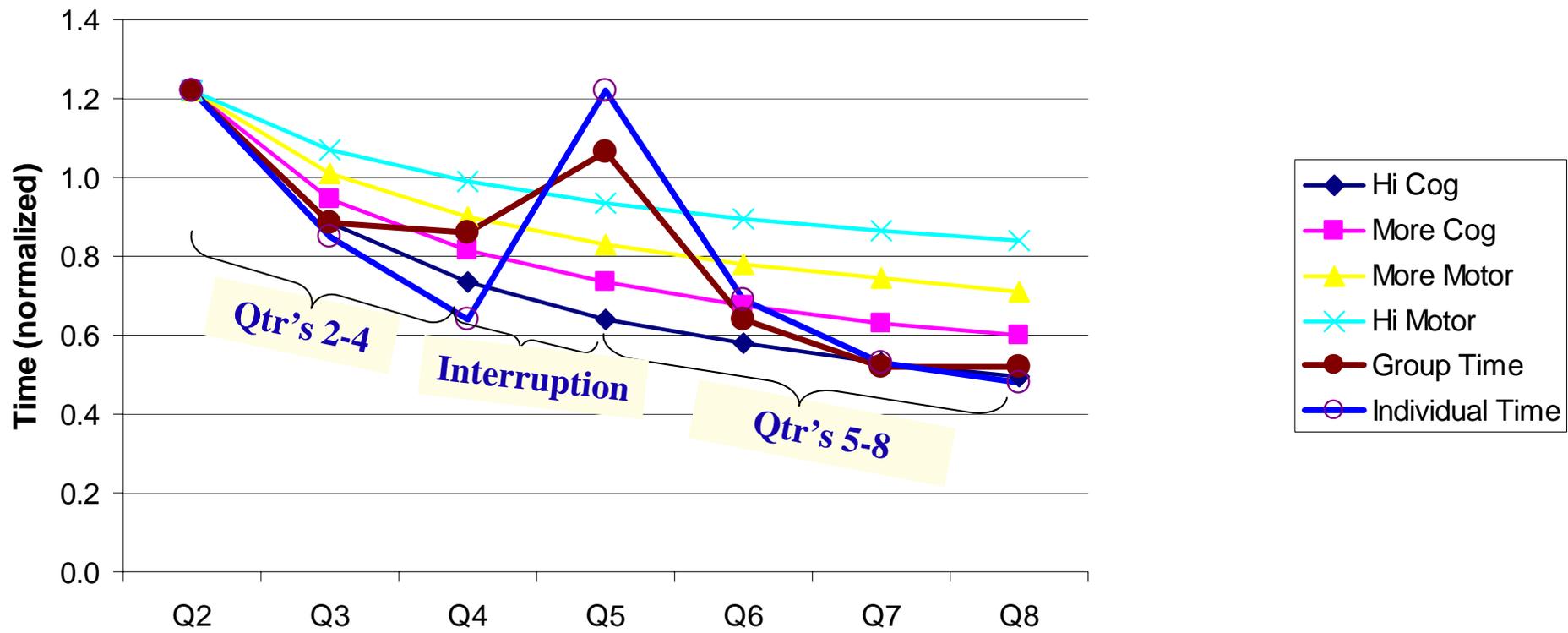




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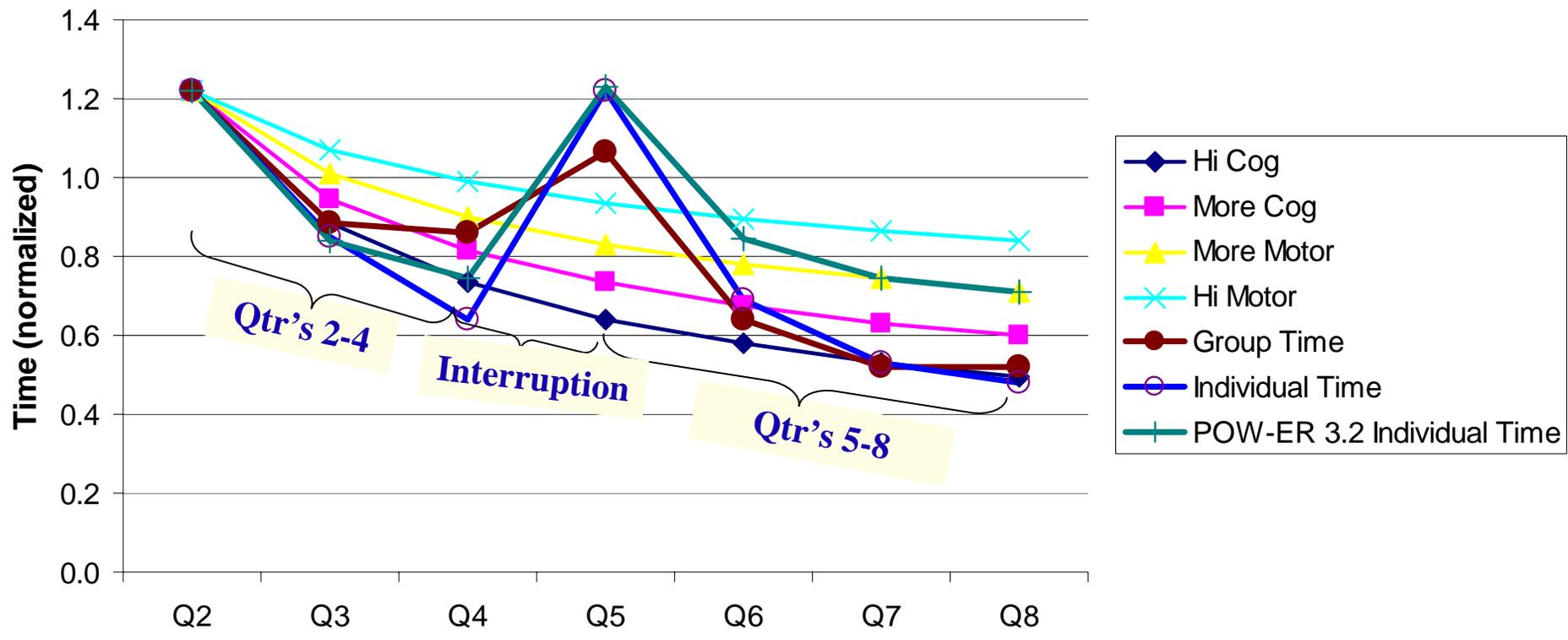




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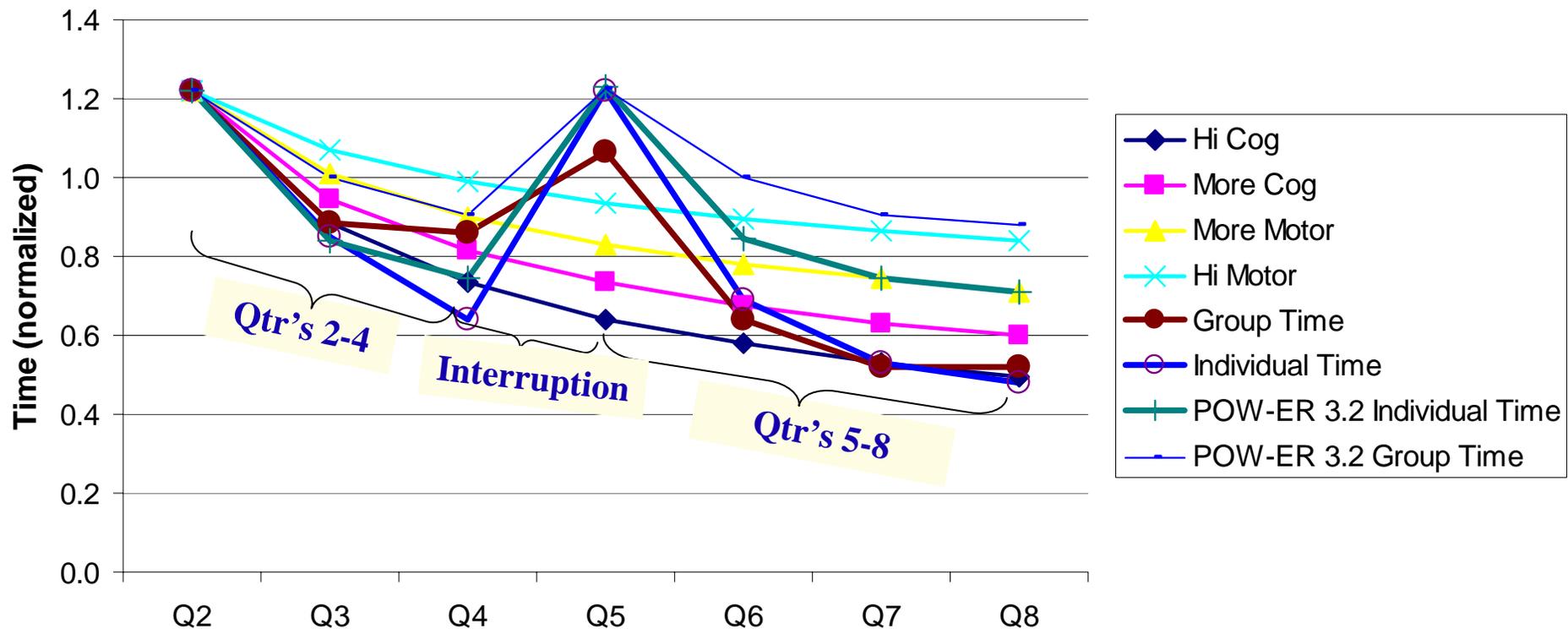




Empirical Validation of Learning Rates

Arousal Exercise

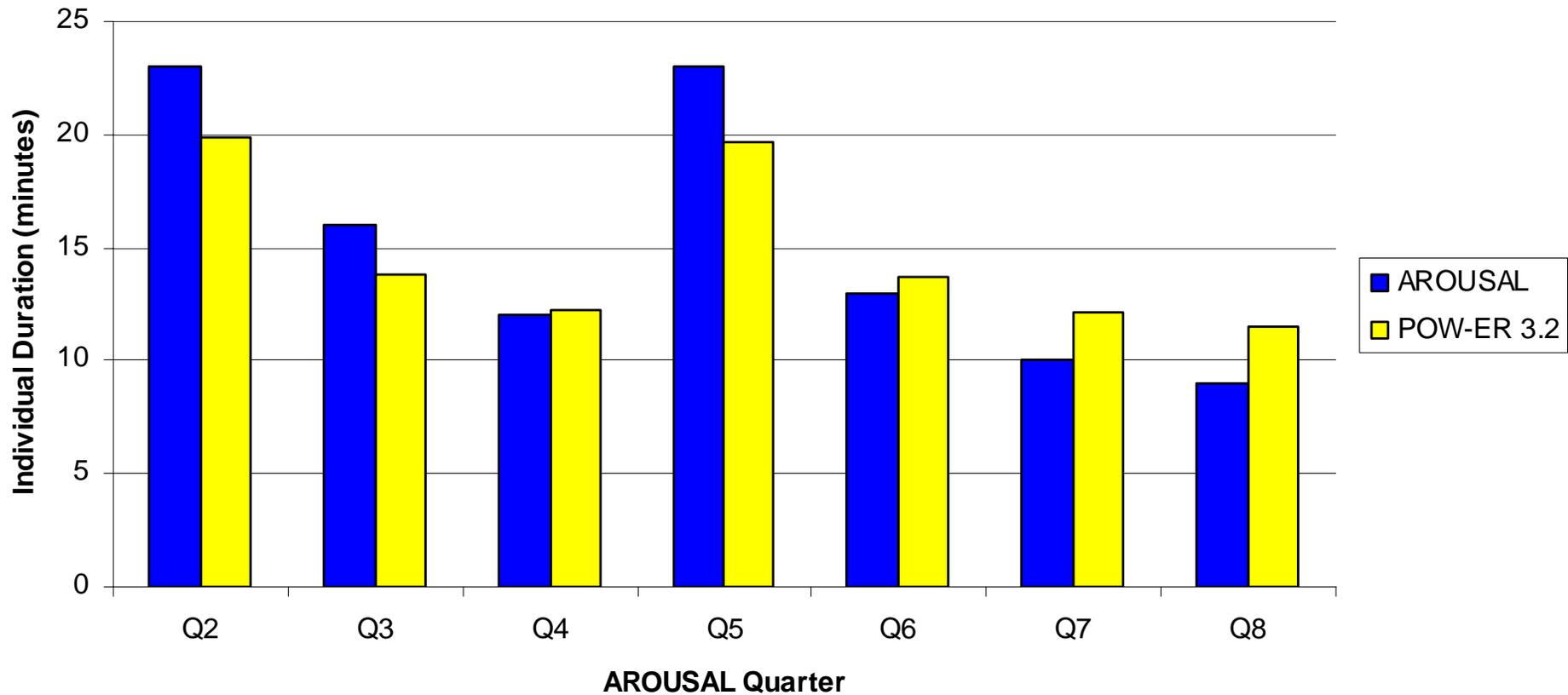
Dar-EI Learning Curves *Plotted Against* Observed Individual & Group Learning Rates





POW-ER Validation

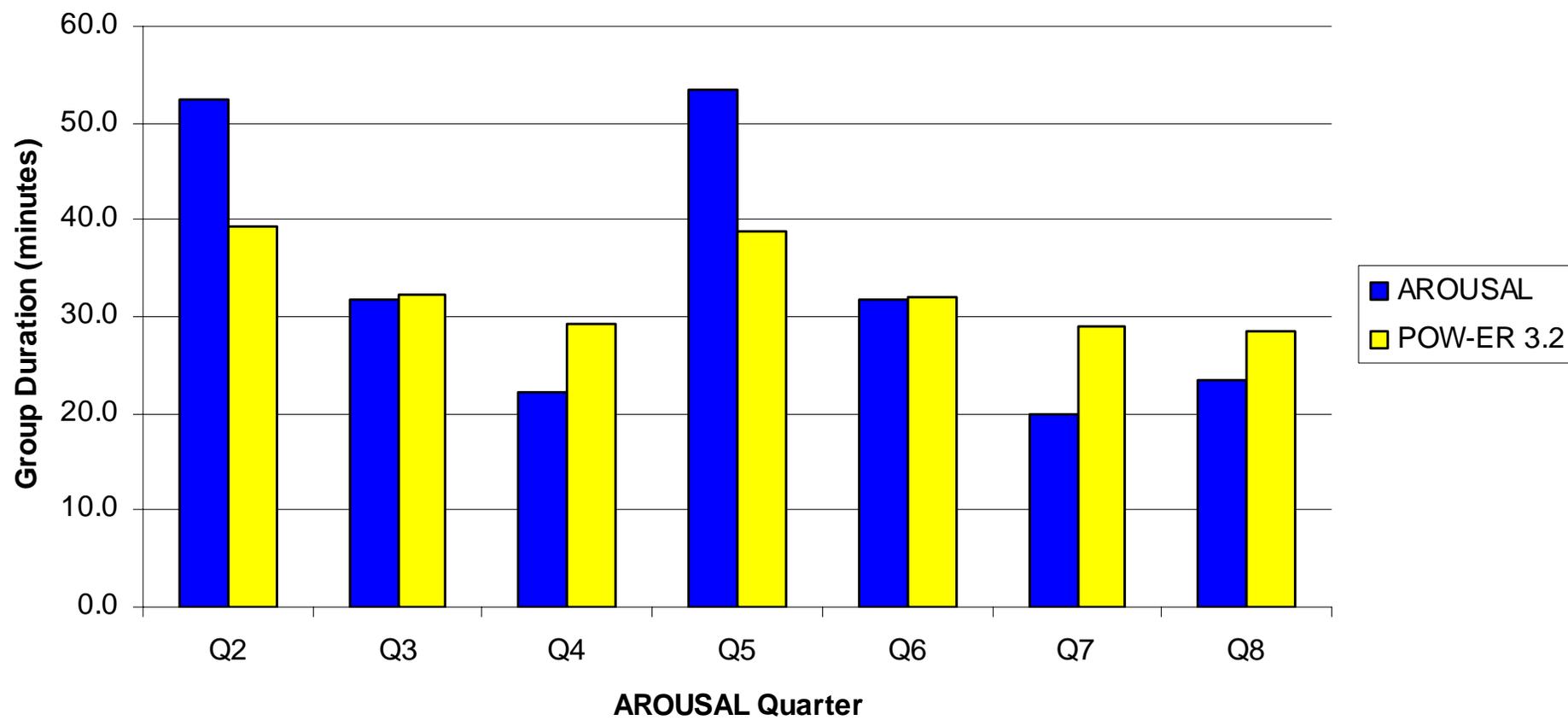
Empirical vs. Predicted Individual Performance





POW-ER Validation

Empirical vs. Predicted **Group** Performance





Organizational Level POW-ER Models

Empirical findings from AROUSAL learning and forgetting

Metric	Individual Data		Group Data	
	Empirical	POW-ER 3.2	Empirical	POW-ER 3.2
Summed individual durations (based on initial period, without subsequent learning)	161 minutes	161 minutes	406 minutes	406 minutes
Duration (with learning)	106 minutes	103 minutes	235 minutes	233 minutes
Percent Savings from Learning	34.2%	36.0%	42.1%	42.6%



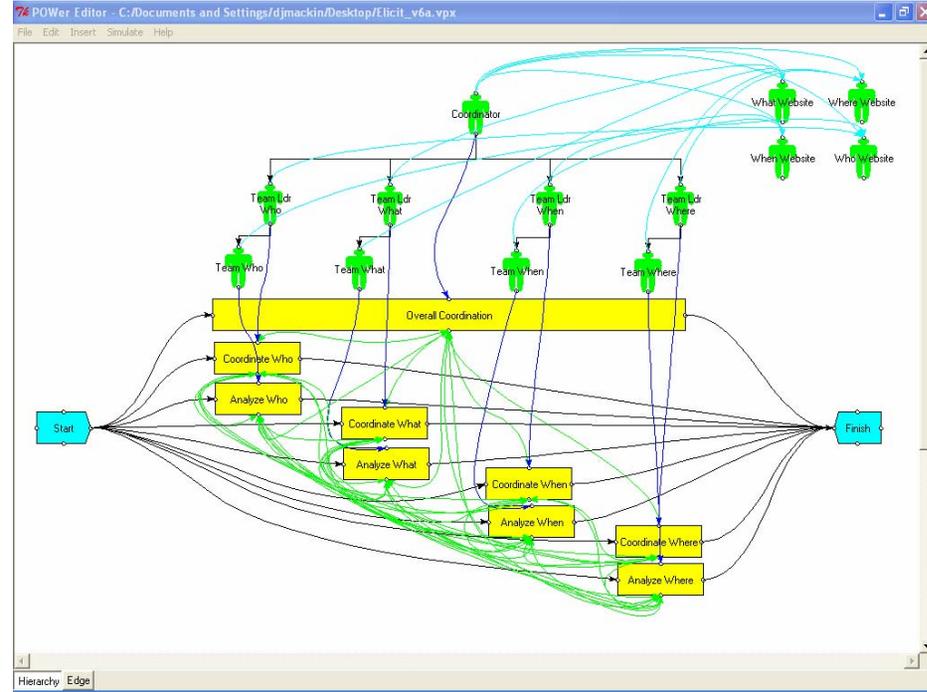
ELICIT Exercise

- 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 approximately 60 minutes



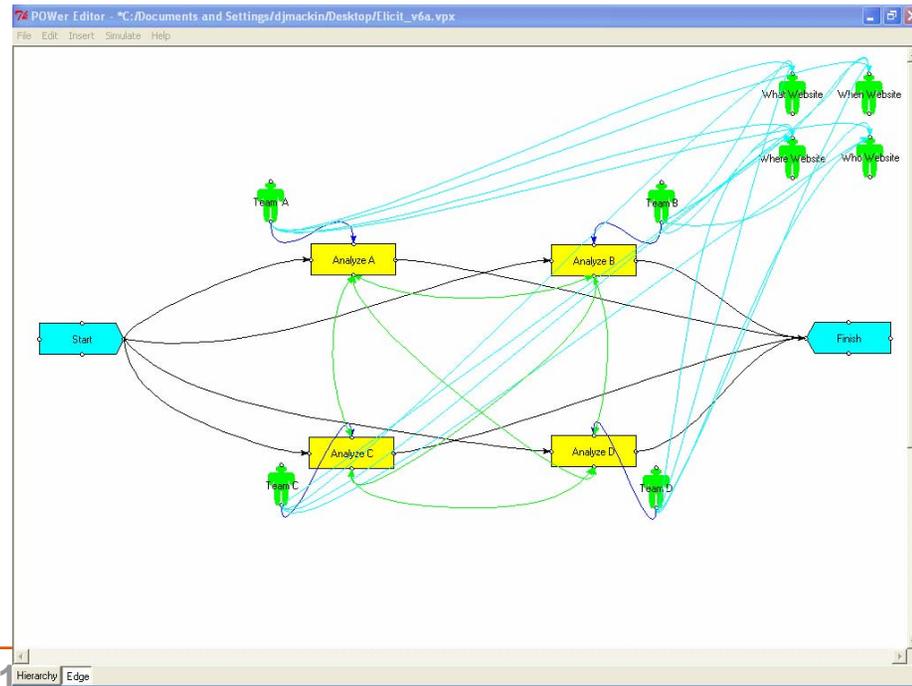
POW-ER Model Validation

ELICIT Exercise



Edge →

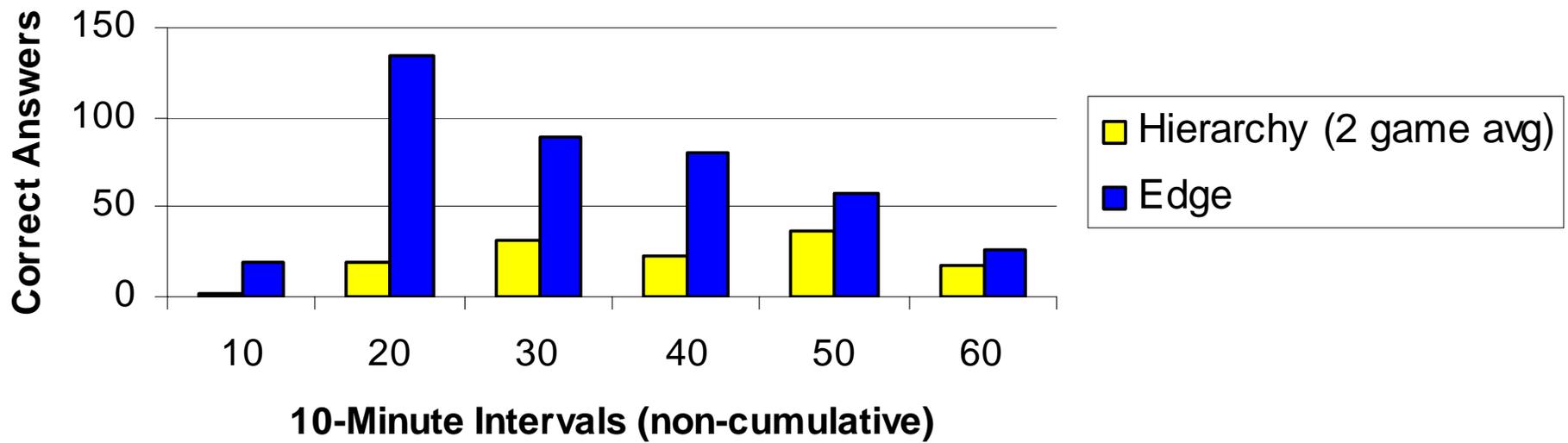
← **Hierarchy**





ELICIT Exercise

Correct Responses in 10-minute Intervals For Different Organizational Forms





POW-ER Experimental Results

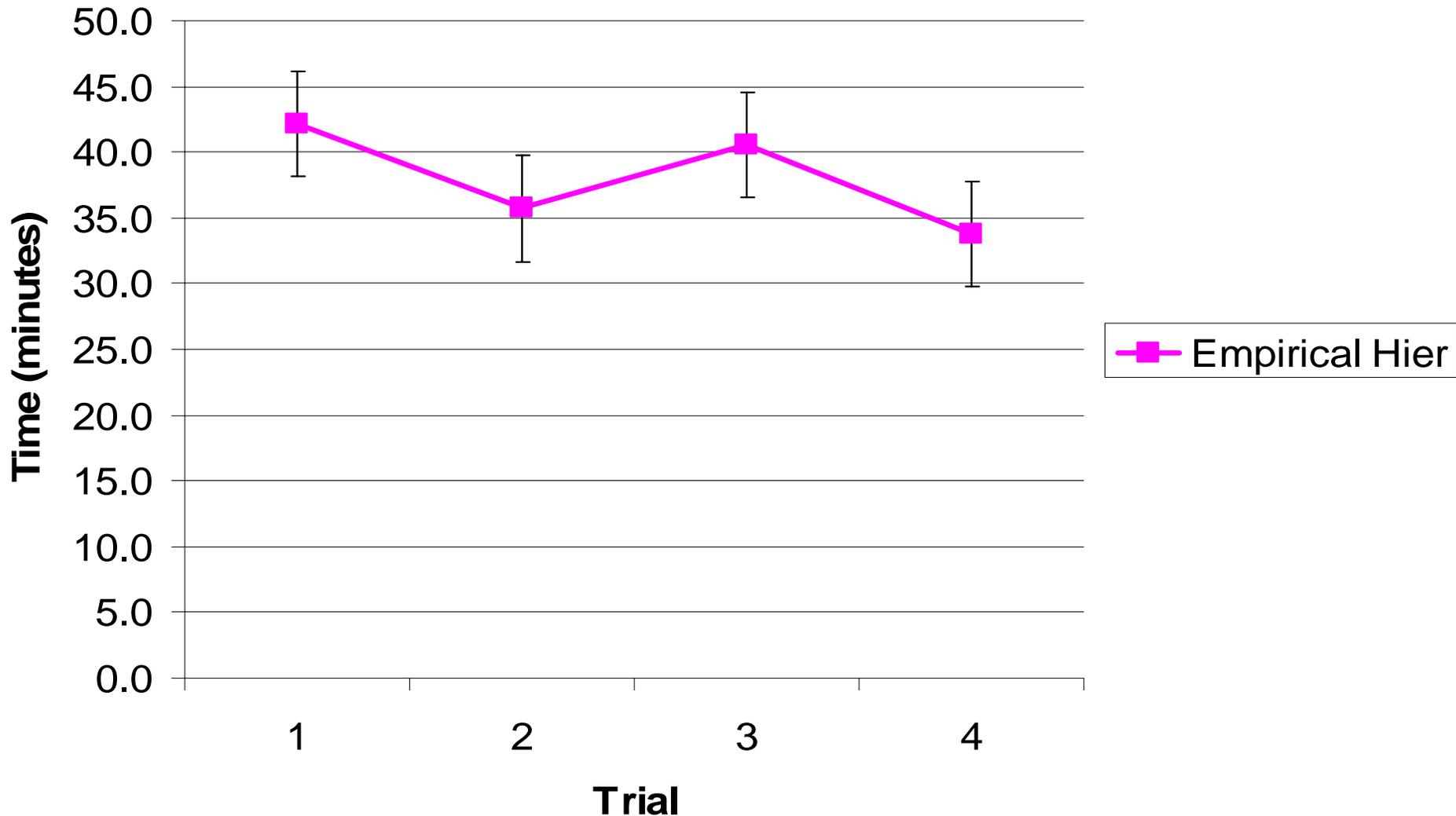
3 Exercise Rounds: 3 day delay after 2nd round

Metric	Hierarchy (3 Rounds) Mean (Std. deviation)		Edge (3 Rounds) Mean (Std. deviation)	
	No learning	With learning and forgetting	No learning	With learning and forgetting
totals				
Duration (minutes)*				
Coordination (minutes)*				
Rework (minutes)				
Functional Exception Work (minutes)				
Total Work (minutes)*				
Functional Risk				
Process Quality Risk				
Cost (\$K)*				



POW-ER External Validity

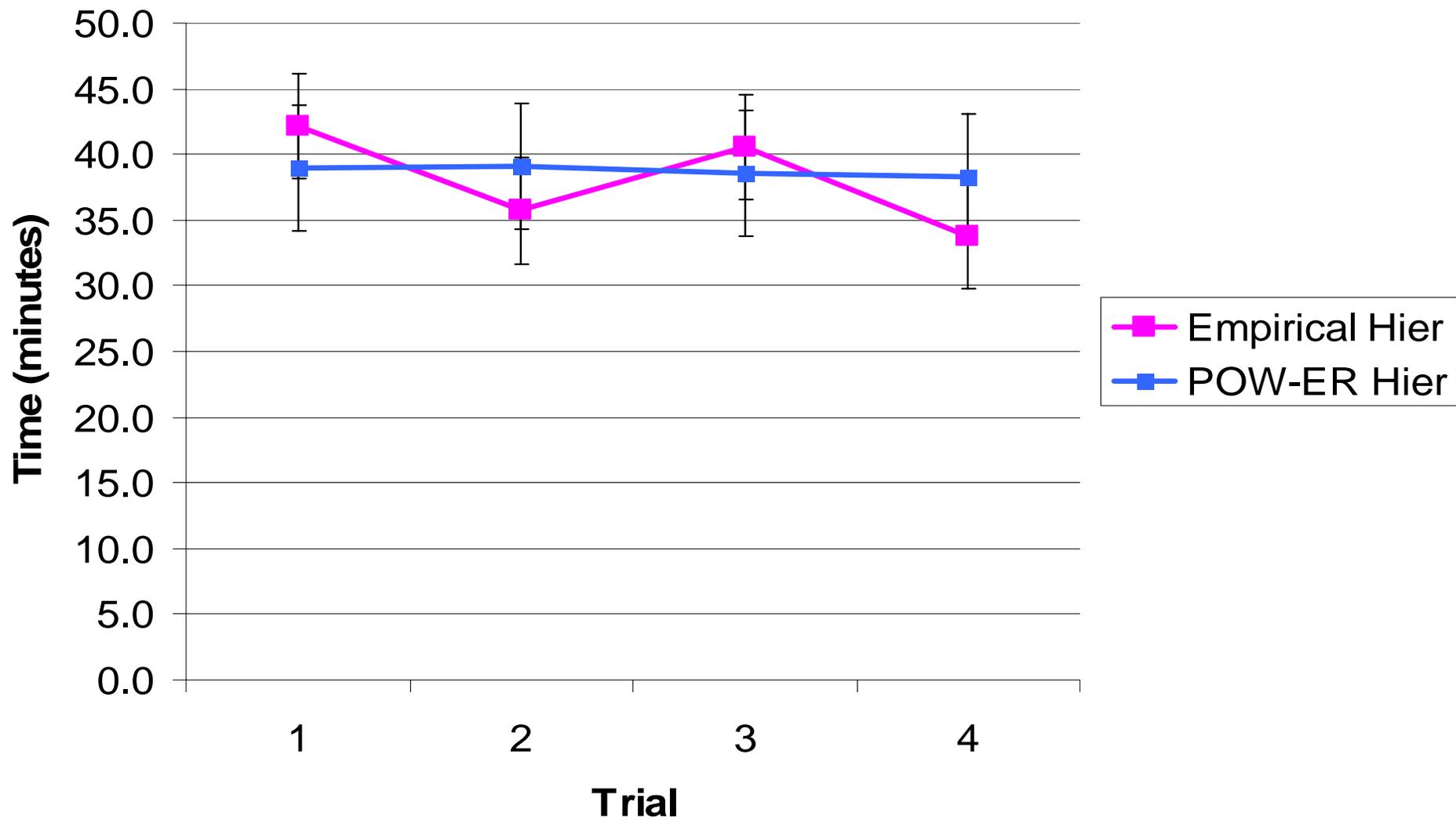
Using ELICIT Observations (Leweling & Nissen, 2007)





POW-ER External Validity

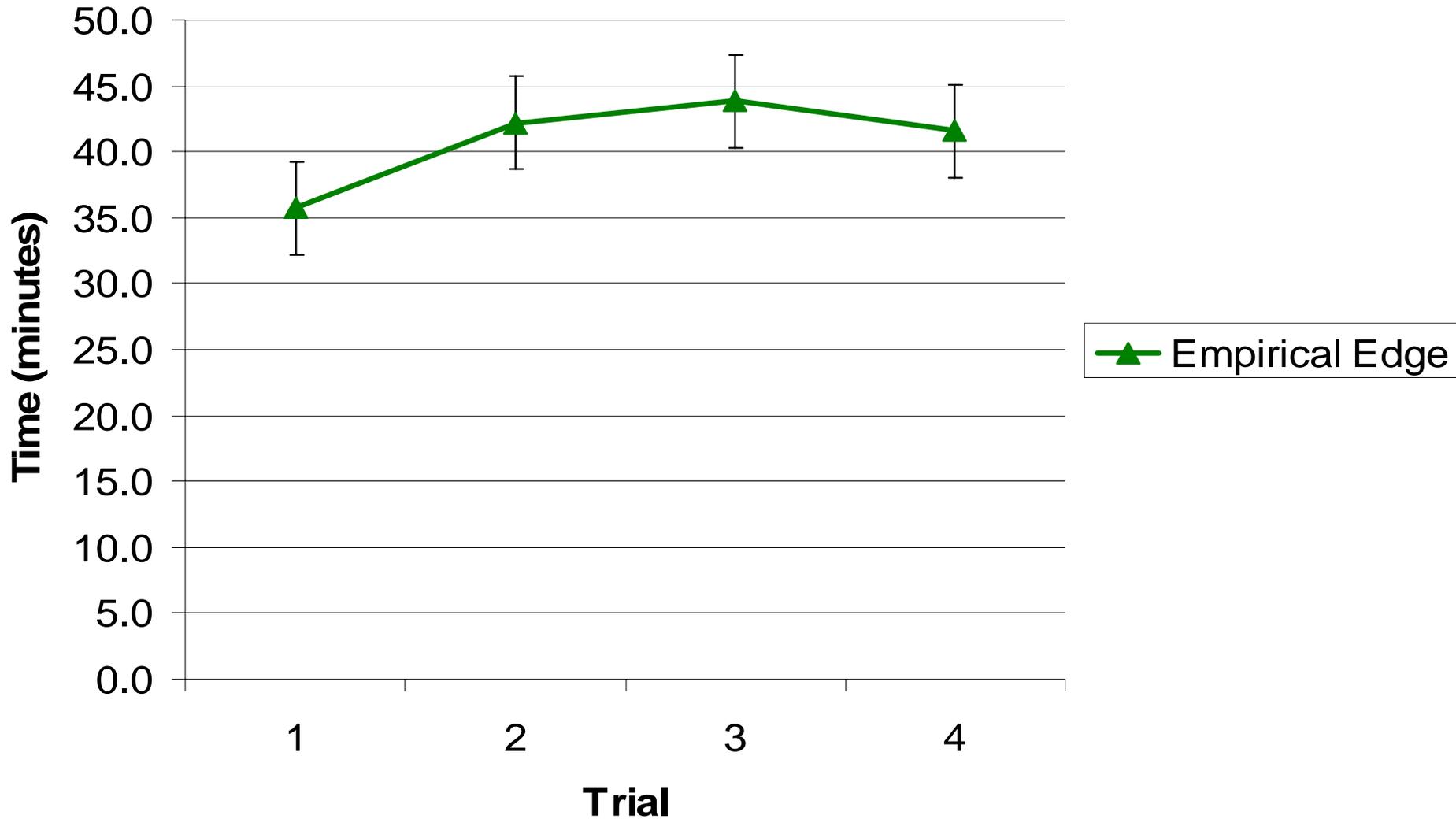
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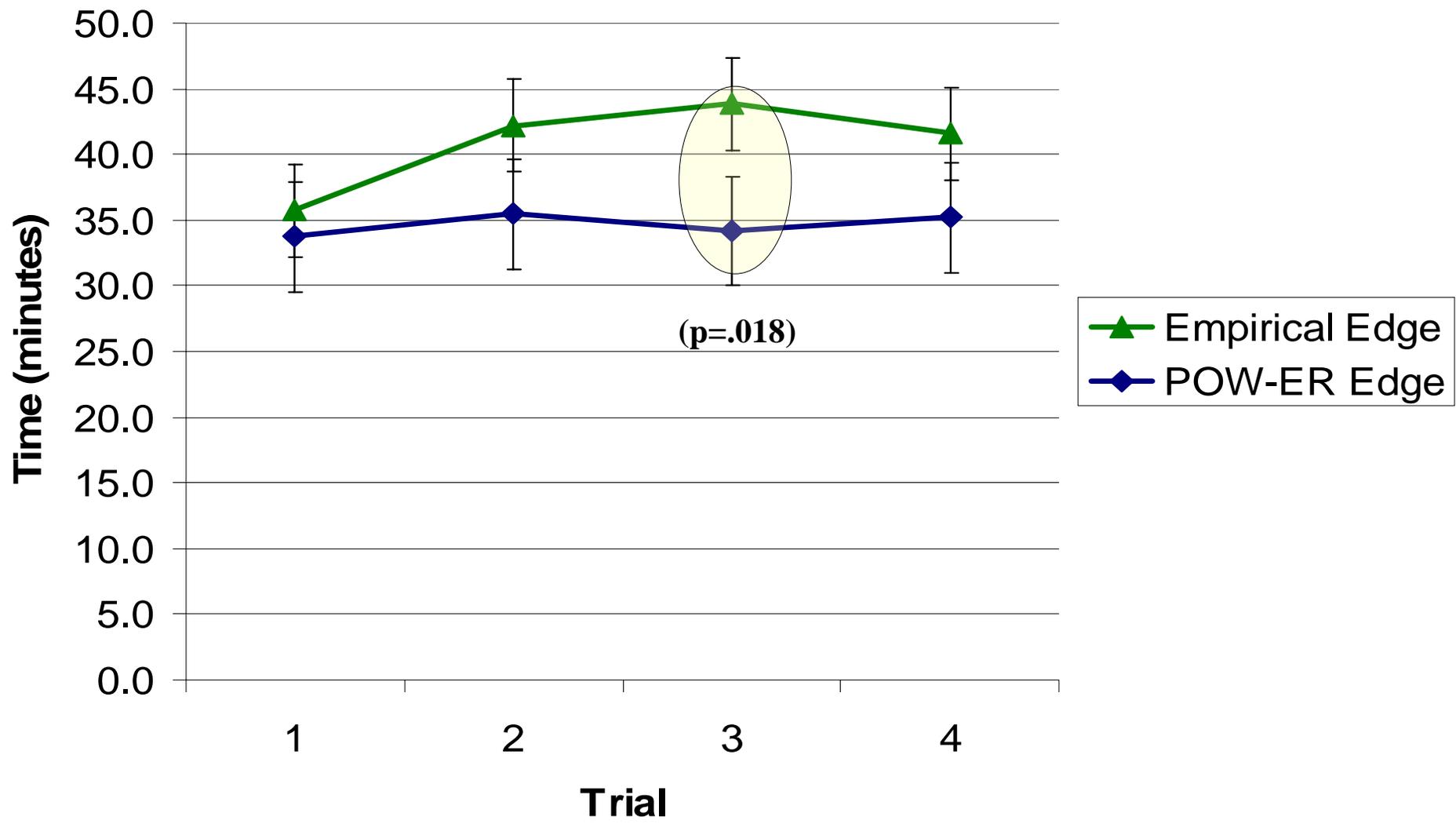
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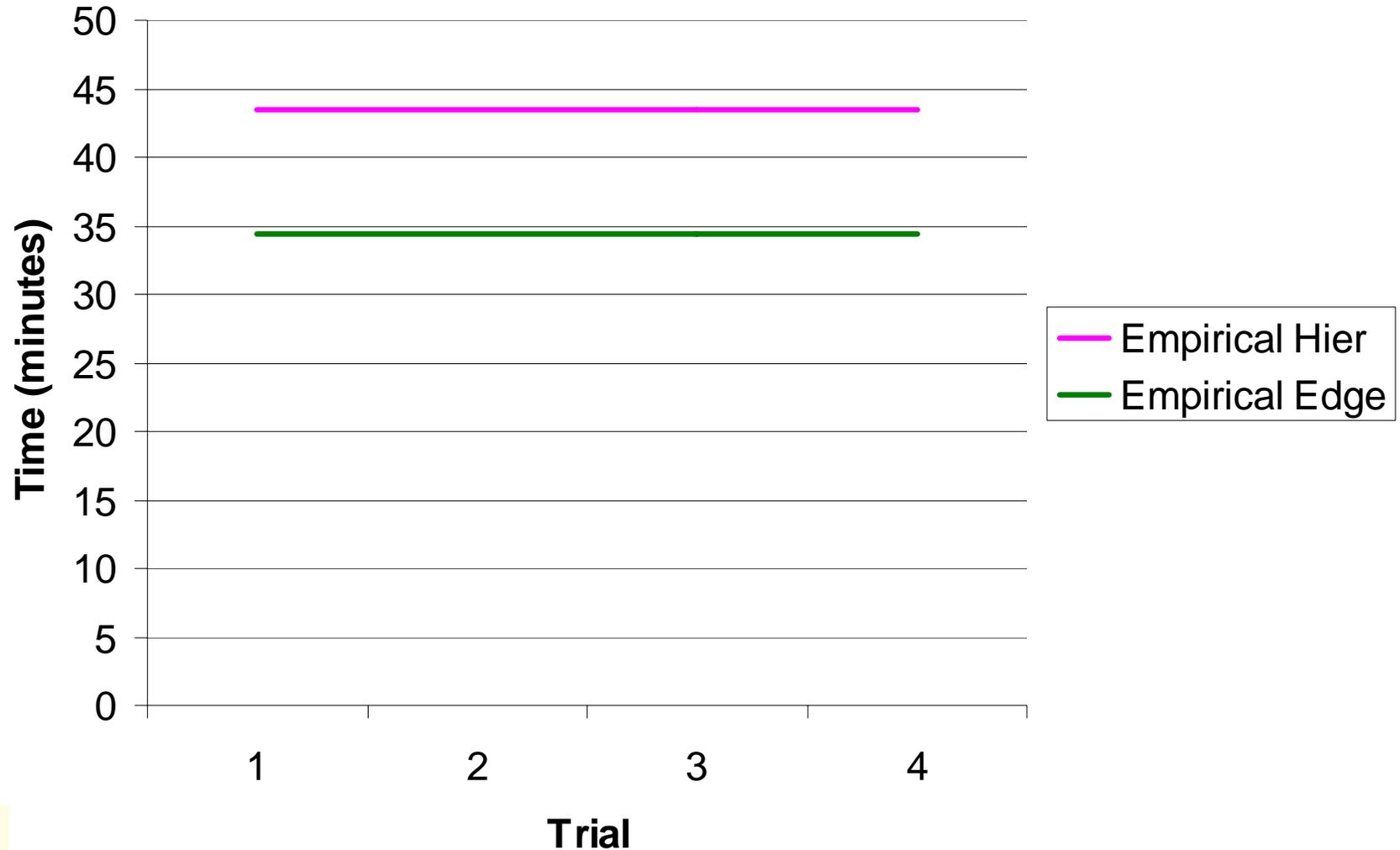
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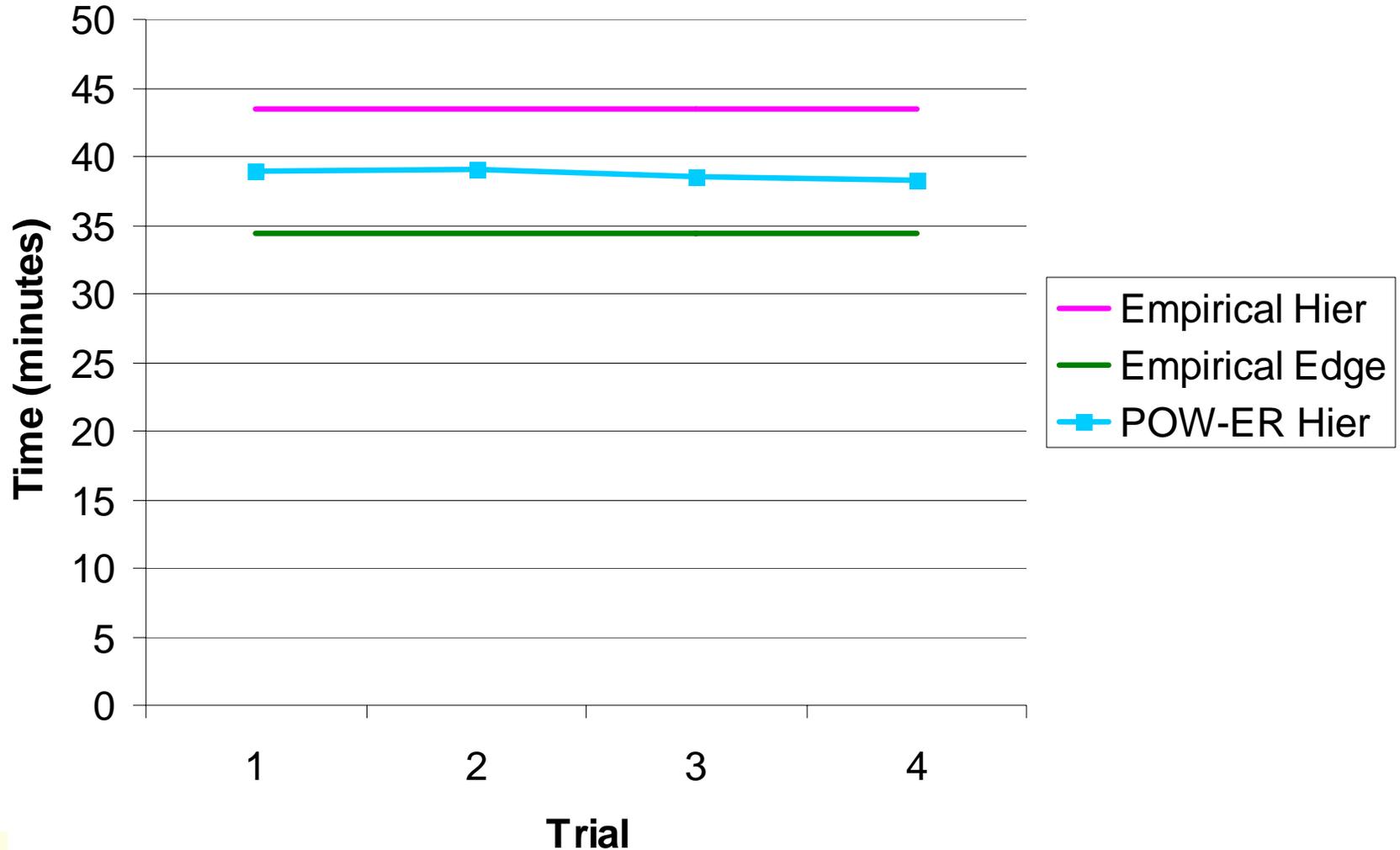
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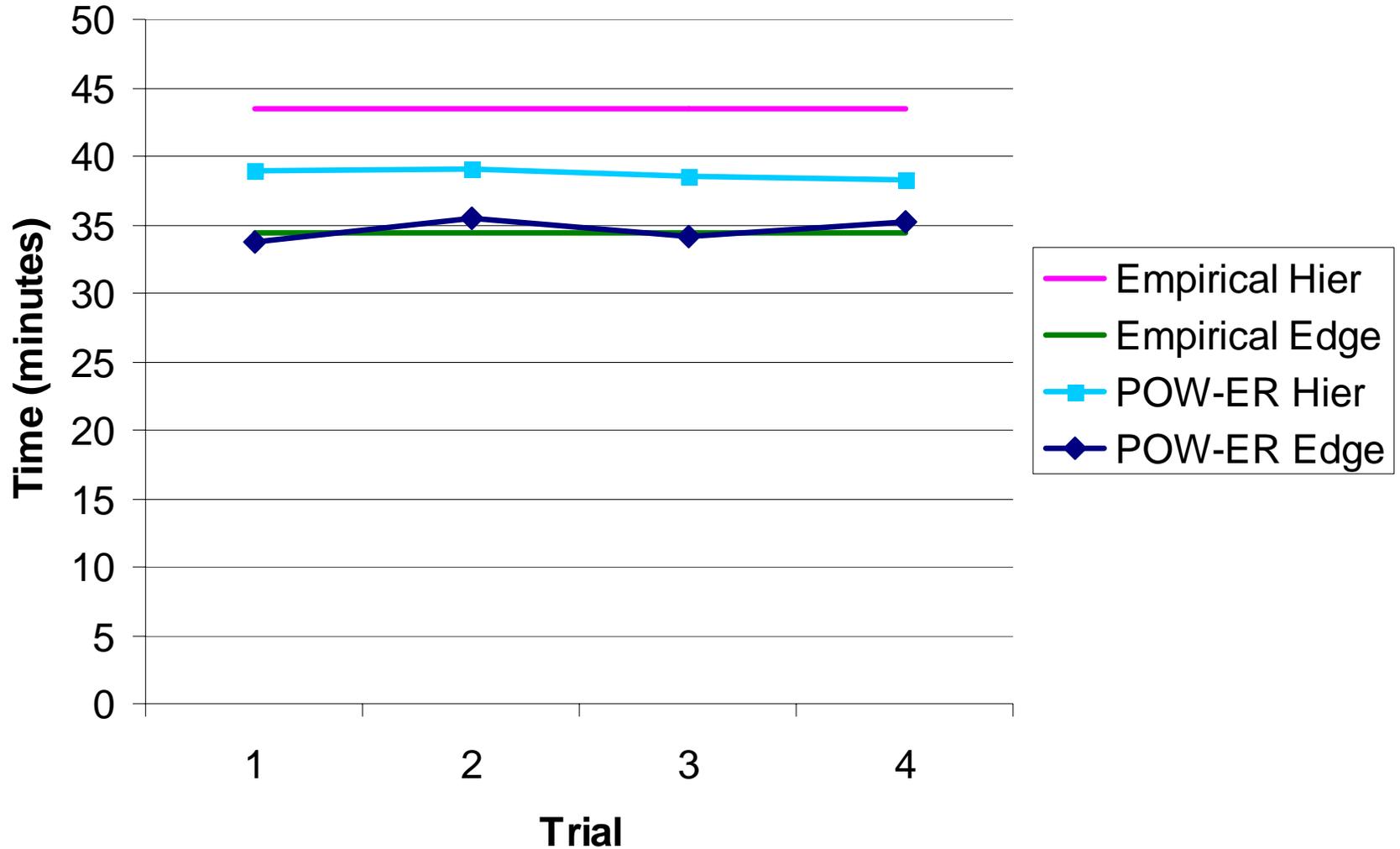
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POW-ER External Validity

Using ELICIT Observations (Leweling & Nissen, 2007)





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



Theoretical Contributions

- Produced quantitative analysis of how micro-behaviors (learning and forgetting) affect organizational performance, extending our understanding of organizational learning
- Calibrated and validated tool to develop and test individual knowledge flow impacts on Edge and other organizational forms



Next Steps

- Develop and validate further via future ELICIT experiments, 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



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