CRGP Collaboratory for Research on Global Projects

Modeling Skill Growth and Decay in Edge Organizations: Near-Optimizing Knowledge & Power Flows (Phase Two)

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CCRTS Paper: C-152

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

Agenda

- Motivation
  - Research Questions
- Phase I Review
  - Inventory theory: Knowledge as a perishable good
- Phase II Efforts
  - Conceptual models: Skill acquisition and decay
- Phase I and II Integration
  - Empirical validation
- Extended agent-based computational model
  - POW-ER experiments
- C2 Application
- Phase III: Next Steps
- Theoretical Contributions

Motivation

- Edge Organization definition
  - No headquarters to rely upon
  - Requires: shared awareness / self synchronization
- Developing and maintaining adequate levels of critical skills is especially crucial 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

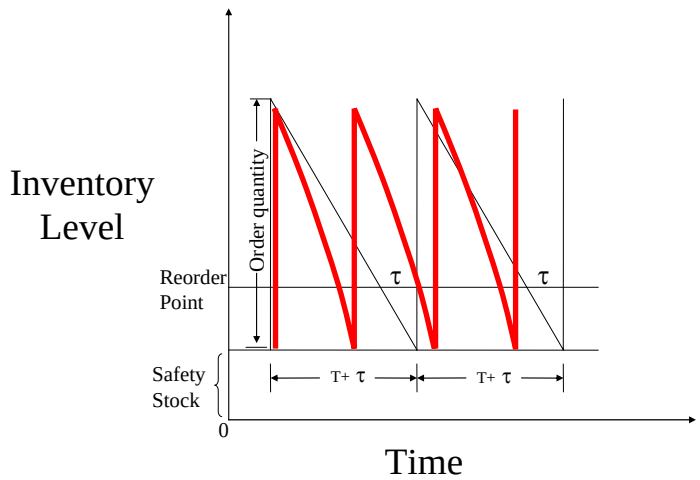
Research Questions

- Phase I:
  - How can inventory theory help to inform our understanding of knowledge flows in Edge Organizations?
- Phase II:
  - How can individual skill acquisition and decay be computationally modeled, calibrated, and validated?
  - How is the performance of Edge project organizations affected by the aggregation of individual participants' skill growth and decay?

Phase I: Inventory Theory
Analysis and Insights

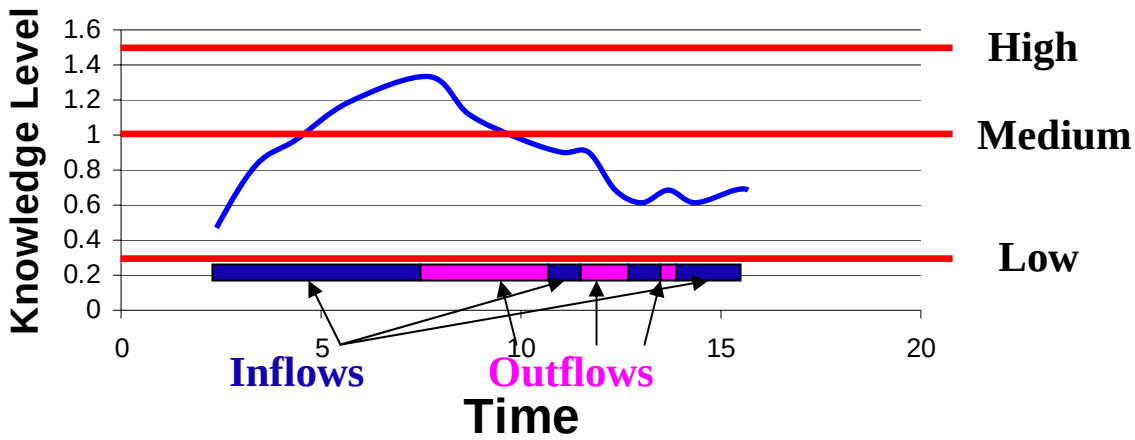
- For a supply chain of perishable goods, managers gain insights considering
  - Economic Order Quantity (EOQ = Q*)
  - Reorder point
  - Make vs. Buy decisions
  - Inventory policies
    - Just-in-Time
    - Just-in-Case

$$Q^* = \sqrt{\frac{2K\lambda}{Ic}}$$

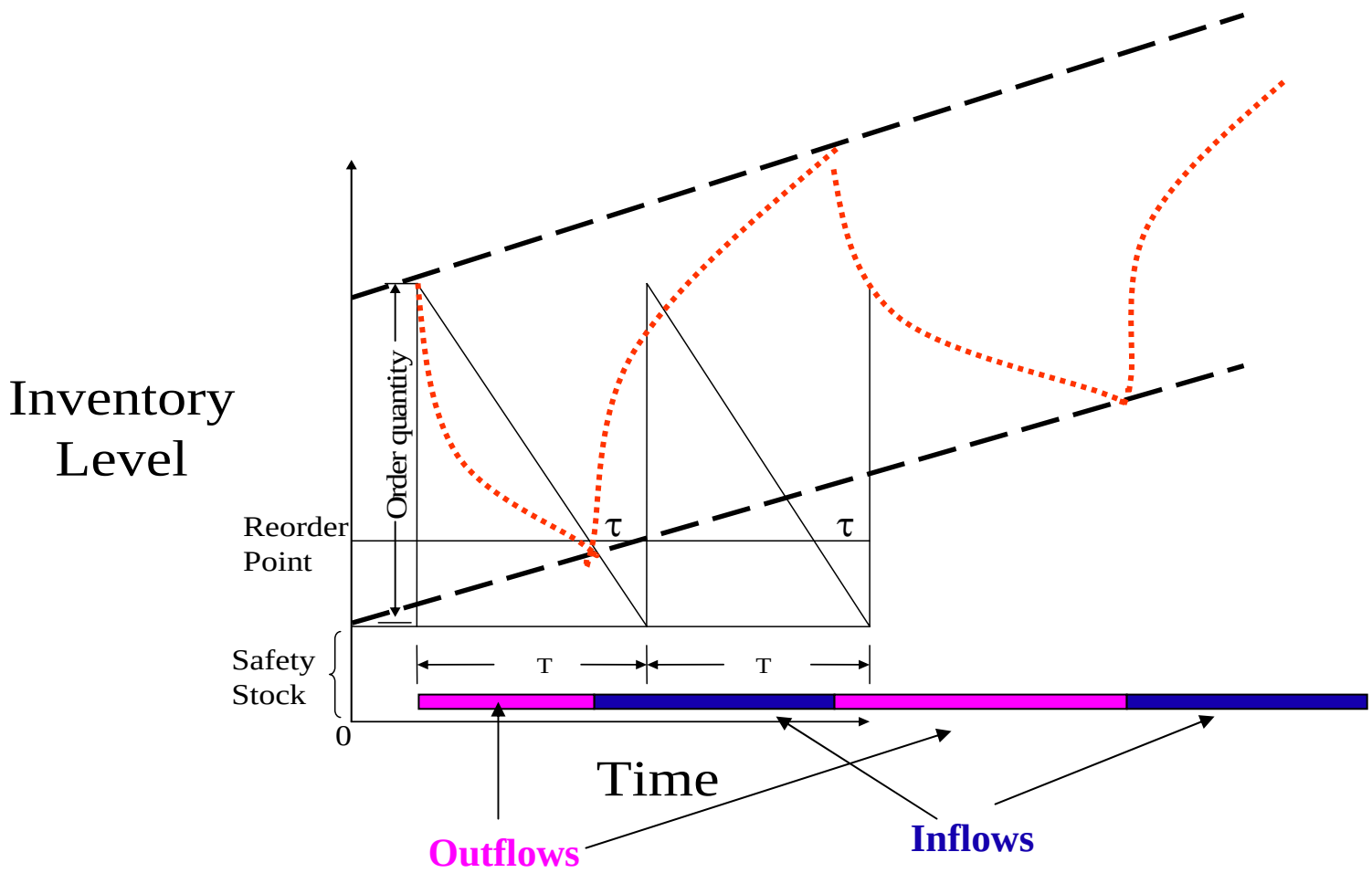


Phase II: Conceptual Model
Individual Skill Acquisition and Decay

- Extensions to POW-ER computational modeling
- Develop fine-grained agent knowledge metric (k/K)
- Provide for dynamic, continuous knowledge over time
- Develop framework to account for agent knowledge
  - Inflows (OJT, formal training, mentoring)
  - Outflows (decay, interference, obsolescence, personnel turnover)



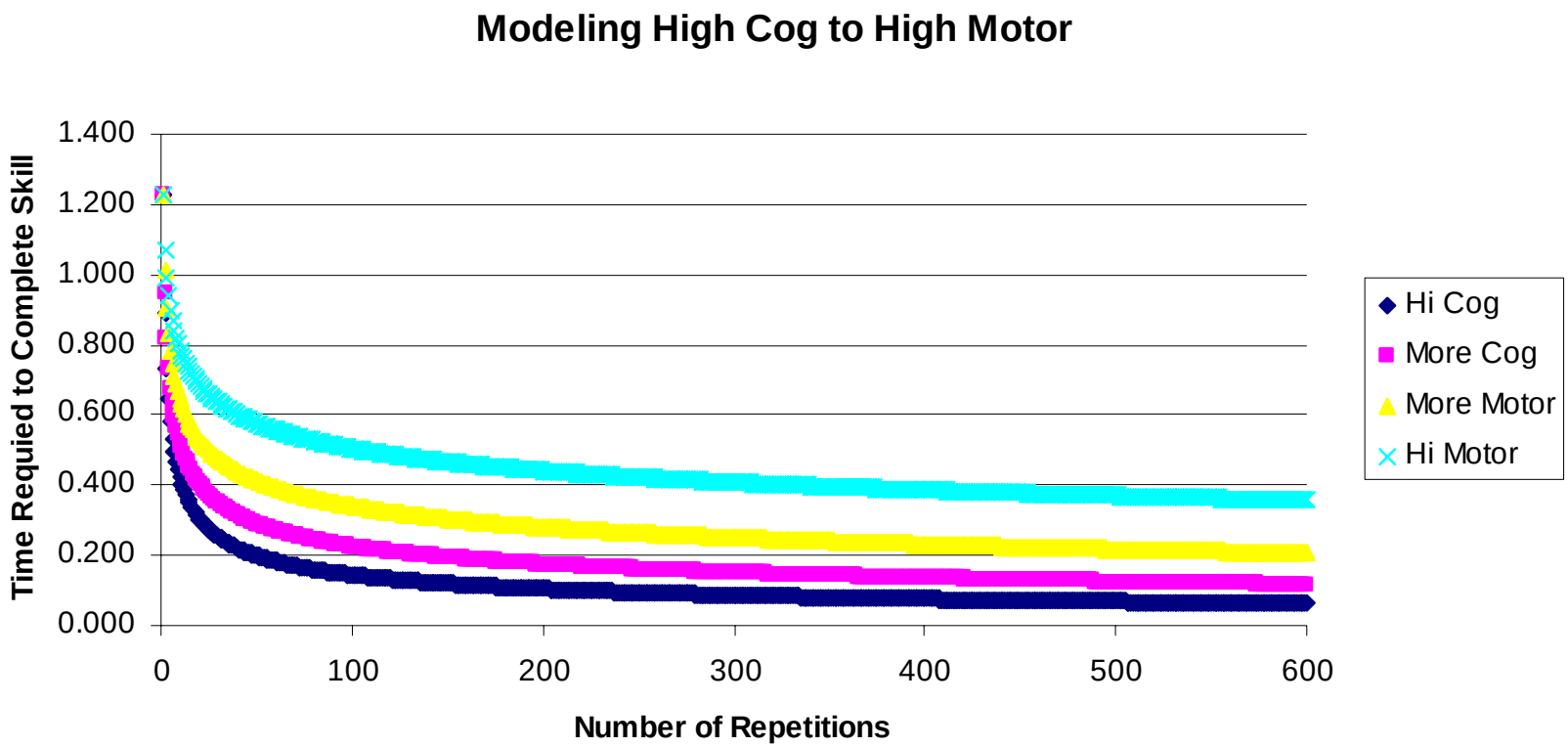
Phase I and II Integration
New conceptual model



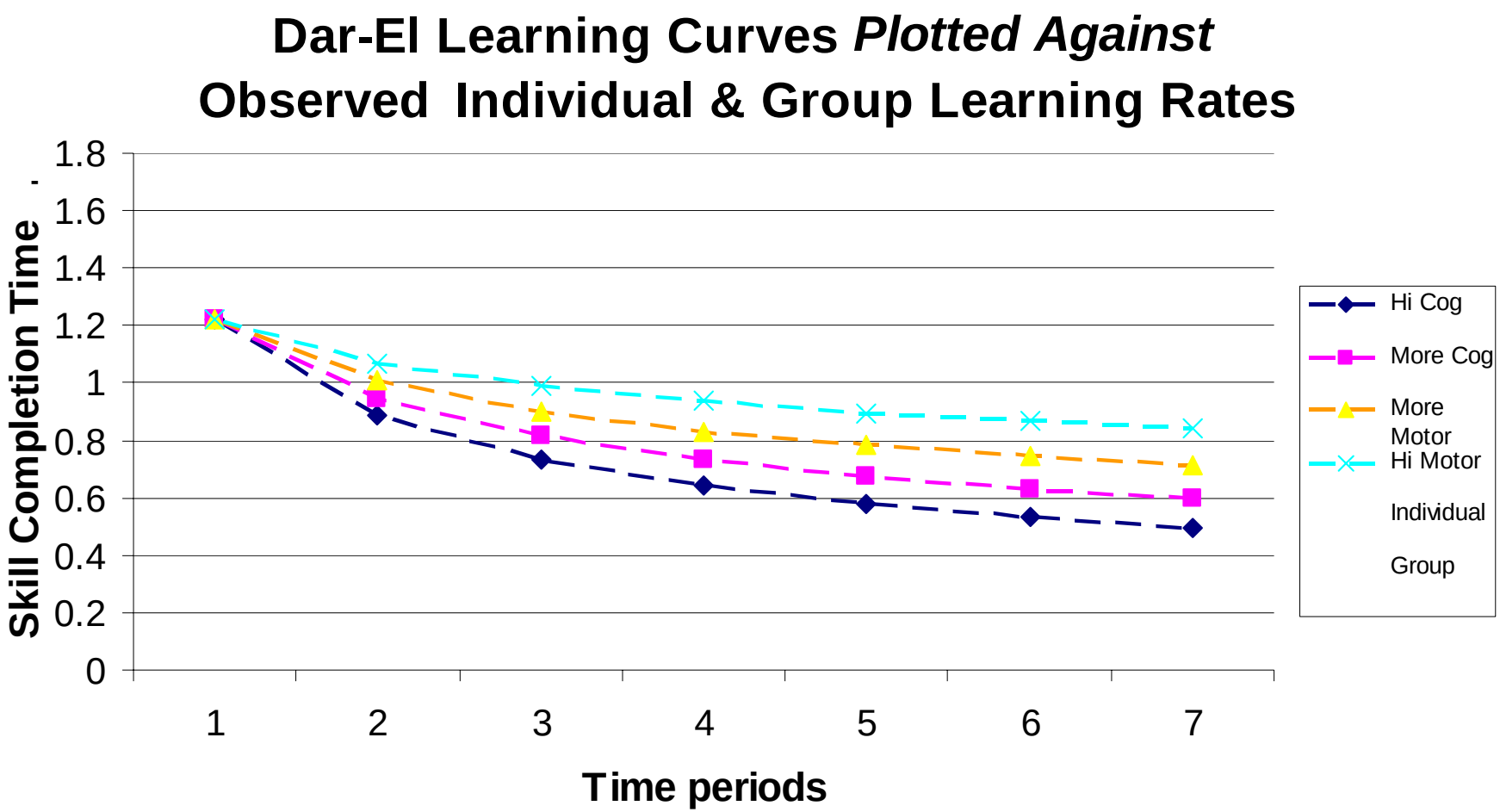
Phase II: Theoretical Point of Departure

Skill Context (Dar-El et al., 1995)

- Different skill types seem to have different learning curves
  - Ranging from highly cognitive to highly motor skills



Empirical Validation of Learning Rates



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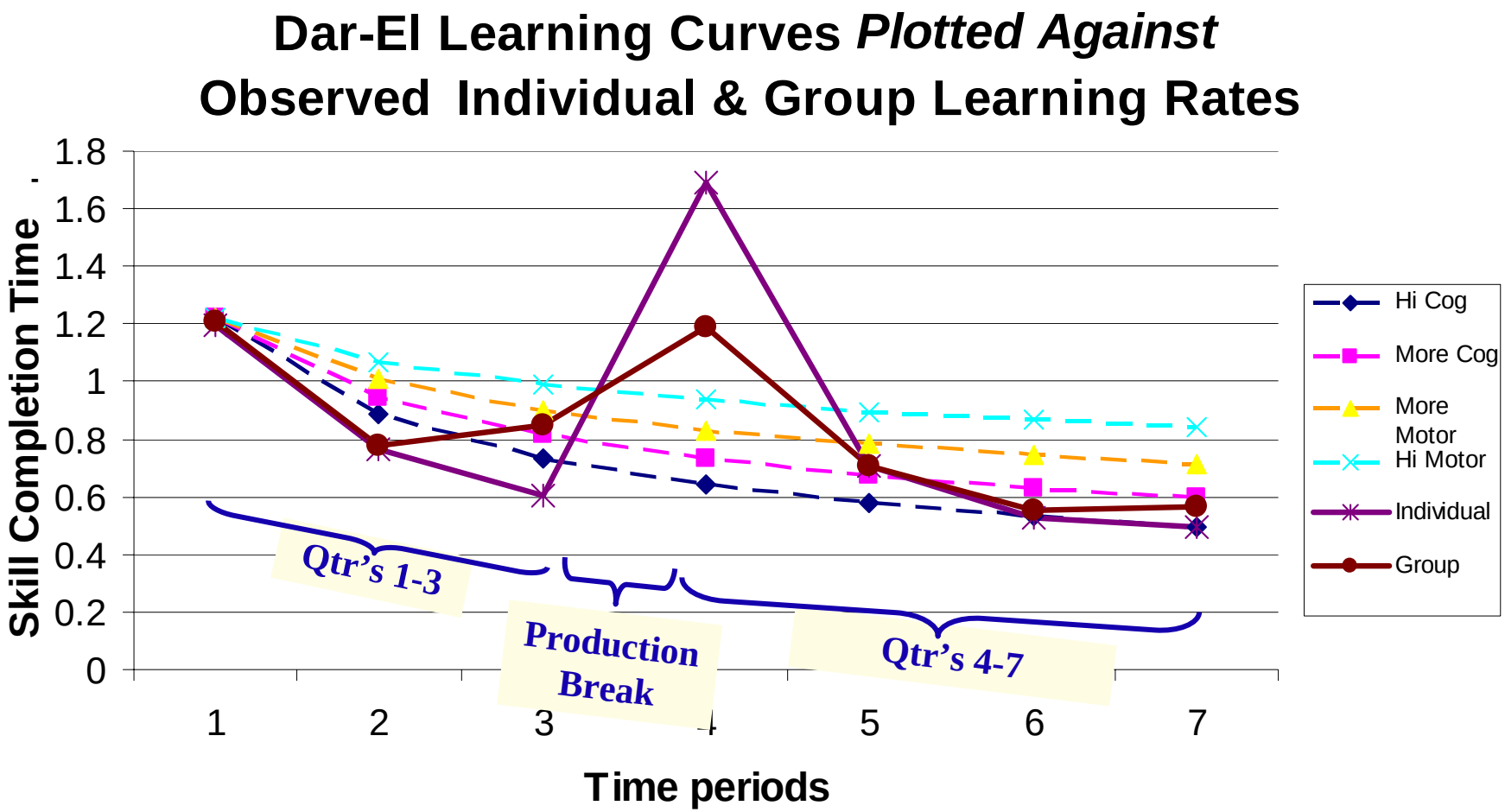
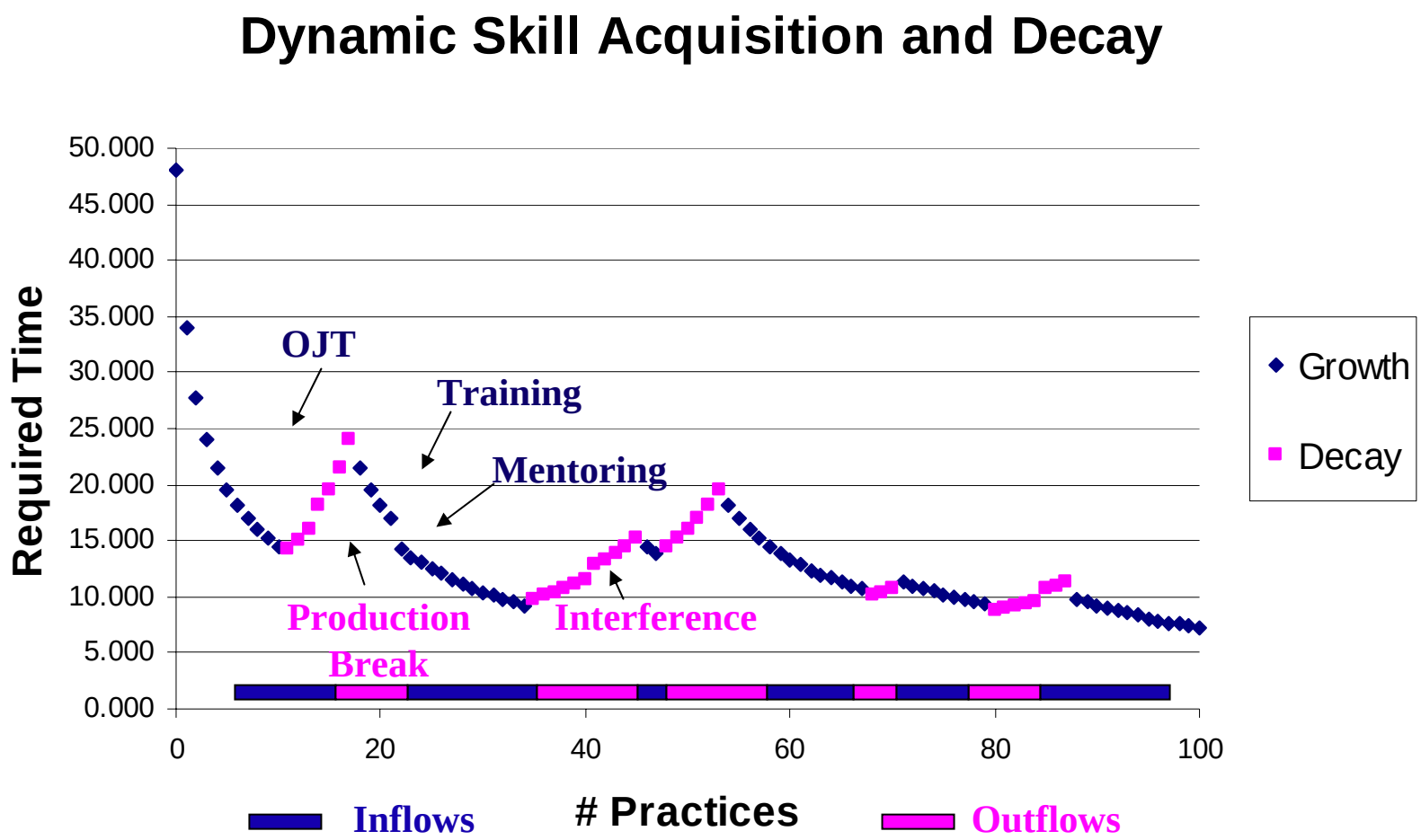


Computational Model

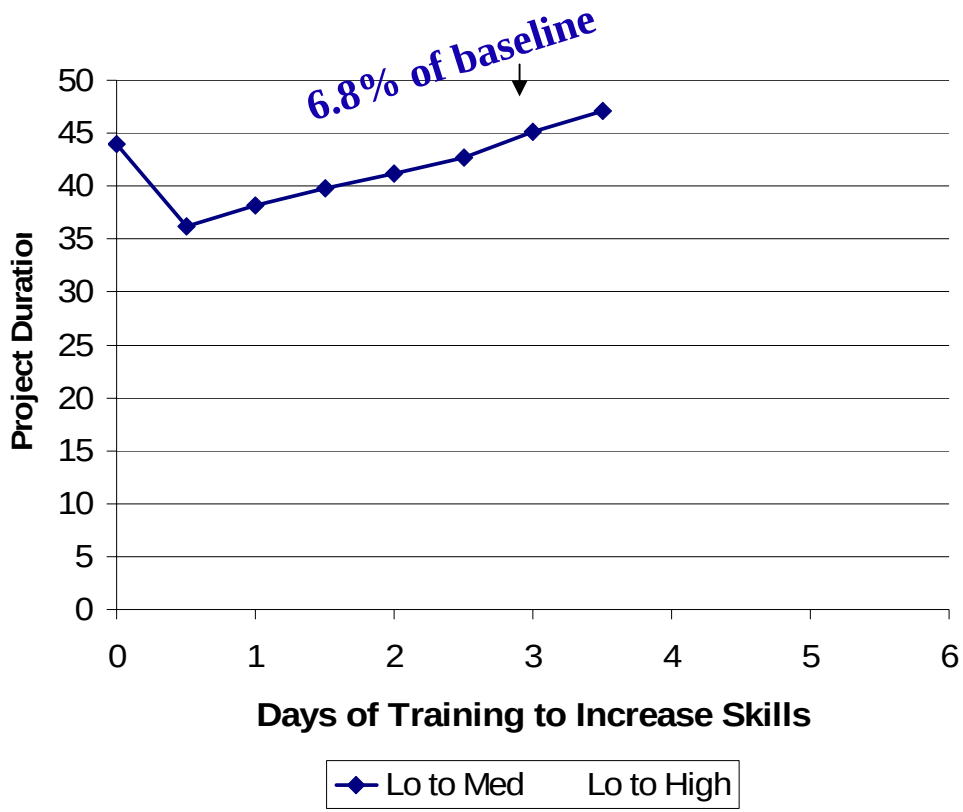


Organizational Level POW-ER Experiments

- Consider the effects on skills and task duration of:
  - Employee training
  - Maintaining knowledge level too high
  - Minimum knowledge level adequate for project

Results from POW-ER Experiments

- Edge employee training
  - Baseline with no training — 45 day project duration
  - Consider impact on project duration of providing training that takes different lengths of time to raise skills from:
    - Low to medium
    - Low to high
  - Graph shows tradeoff of:
    - Production time lost to training vs.
    - Production time gained by increase in production rate with higher skill after training



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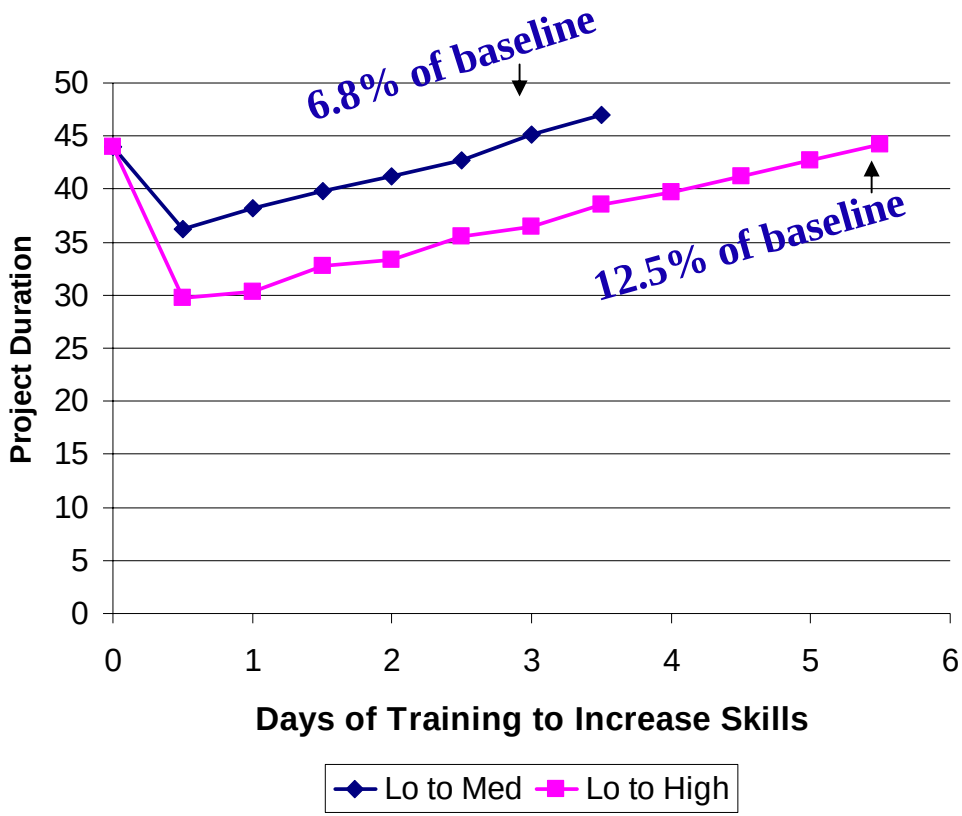

C2 Application

- Knowledge as perishable inventory provides framework
- Example: Crew training (deployment preparation)
  - Consider inventory model with learning curves
    - Knowledge interventions
      - Inflows and outflows
    - Lead time consideration
    - Safety stock
    - Frequency and magnitude of “reordering” increases to maintain proficiency
      - Example: ASW vs. Damage Control training

Phase III: Next Steps

- Compare empirical findings to extant cognitive psychology literature
- Leverage results to develop and validate a computational model
  - To predict project lengths for a single project
  - Based on agent growth and decay of skills and interactions between agents (e.g., mentoring)
- Develop MatLab$_{tm}$ model
  - To predict knowledge inventories in a project team
    - Given knowledge growth and decay interventions
  - Based on supply chain theory for perishable goods
- Make predictions about organizational knowledge inventories
  - In a set of Just-In-Time/Case scenarios
  - Compare predictions from MatLab$_{tm}$ model to simulation model

Theoretical Contributions

- Phase I
  - New knowledge concerning how inventory theory can inform knowledge flows in Edge organizations
- Phase II
  - Extend the capability of computational modeling to reflect optimally contingent knowledge flow in Edge and other organizations
  - Provide preliminary computational model to predict how Edge organizations and projects are effected by the sum of individual participants' skill growth and decay
- Phase III
  - Produce "engineering" knowledge management solutions in organizations via a *Knowledge Chain Management* approach

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