Experiment Thrust

*Developing Theoretical Concepts for Experimentation*

Theoretical Concepts for Experimentation

Developing Theoretical Concepts for Experimentation

- Parallel approach to Experimentation Thrust
  - Overall focus on augmenting and developing macrocognition concepts
- A) Asking how can we enrich understanding of foundational collaboration concepts through empirical studies?
- B) Testing macrocognition concepts through refined measurement techniques

A) Presenting overarching concepts for macrocognition experiments
- Understanding Problem Space and Impact of Task

B) Discussing metrics experimentation to support more diagnostic and construct valid understanding of macrocognition
Overarching Research Questions for SUMMIT Experimentation

- **How do task factors alter macrocognitive processes?**
  - How do changes to task complexity (e.g., low versus high integrative complexity) impact macrocognitive stages and/or processes?
  - How do changes to task structure (e.g., ill-structured versus well-structured) impact the manner in which teams collaborate as they work through macrocognitive stages and/or processes?

- **How does distributed interaction influence differing elements of collaboration?**
  - What happens to information processing within and across teams when members are not all co-located?
  - How do changes to the task interact with distributed interaction?

- **What is the impact of agent-based team members?**
  - How does inclusion of agents supporting certain macrocognitive processes impact overall stages and/or processes?
  - Do task variations interact with inclusion of agents in their impact on macrocognition?

- **Can we triangulate on macrocognitive processes through improved measures?**
  - What measures provide the most diagnostic utility as to assessing macrocognition across the stages of collaborative problem solving?
Macrocognition and Experimentation with Task Variation

**Background**
- CKI program now looking at macrocognition in varied tasks

**SUMMIT Goal**
- Assess how variation of theoretically important factors, within a given testbed, alters macrocognition

**Rationale**
- *Practical Significance*
  - Research across variety of situational factors would support understanding and improving operational performance

- *Theoretical Significance*
  - Research on macrocognition would benefit from further integration of cognitive science concepts
  - *Task classifications would clarify influence of task structure and complexity to help better understand macrocognition*
Developing Theoretical Concepts for Experimentation

Macrocognition – *Problem Space and Influence of Task*

- Understanding problem space theory in context of macrocognition (Newell & Simon, 1972)
  - the mental space in which the problem solver must encode problem elements -- defining goals, rules and other aspects of the situation... [that] represent:
    - the initial situation presented
    - the desired goal situation
    - various intermediate states, imagined or experienced
Theoretical Concepts for Experimentation

Macrocognition - **Problem Space and Influence of Task**

- **Reifying Problem Space Concept through Operationalization of Task Variability**
  - *Question is how do task factors alter problem space*
  - The task defines the “topology” of the problem space
    - *Dictates paths through the problem space available to the problem solver*
    - *Some successfully lead to solution*
    - *Collaborative process determines path choice*

- **Experimentation will explore how this alters macrocognitive processes**
  - **Overarching Hypothesis**
    - *Differential impact of task manipulations on subcomponents of macrocognition*
    - *For example, there will changes to quantity and quality of knowledge building when task is more ill-structured?*
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Macrocognition - *Problem Space and Influence of Task*

Theoretical Issue – Problem Space and Task Complexity (Wood, 1986)

- **Component Complexity**
  - Amount of distinct acts associated with task and amount of cues/problem elements to be processed

- **Coordinative Complexity**
  - Degree to which task variables need to be integrated for successful task completion

<table>
<thead>
<tr>
<th>Task Complexity</th>
<th>Component Complexity</th>
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<td>Low</td>
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<td>Coordinative Complexity</td>
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Theoretical Concepts for Experimentation

Macrocognition - *Problem Space and Influence of Task*

Theoretical Issue – Problem Space and Task Structure (Campbell, 1991)

- Determined by the number of task paths to follow and/or the amount of ambiguity or uncertainty associated with the paths.

  - **Multiple Paths**
    - Degree to which distinct outcomes are possible in task environment

  - **Degrees of Uncertainty**
    - Degree to which task alternatives are:
      - Ambiguous as to the path elements and/or
      - Differ in likelihood of occurring (i.e., amount of ambiguity associated with outcomes)

<table>
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**Theoretical Concepts for Experimentation**

- **Task Complexity** - *Component Complexity* in SUMMIT
  - Amount of distinct acts associated with task and amount of cues/problem elements to be processed
  - MACRO-COG missions composed of several operations
    - Manipulating number of operations increases component complexity
      - For example, plans required for each operation - the more elements required in the plan the more complexity
  - Also number of resources, team members, and rules will be varied to manipulate component complexity

**NEO-based Scenario Development**

Rebel forces attempting to overthrow government. Generate plans to aid government and civilians.

**Iterative Planning Scenario**
- Multiple planning events at different locations
- Various constraints including interdependencies and resource limitations
- Five team members:
  - Weather/Environment
  - Supply Specialist
  - Transportation
  - Intel 1 (Local)
  - Intel 2 (Global)
Theoretical Concepts for Experimentation

- **Task Complexity - Coordinative Complexity** in SUMMIT
  - Degree to which task variables need to be integrated for successful task completion
  - MACRO-COG allows for manipulating interdependencies between roles
    - For example, weather person knows critical for equipment person (who needs to decide if it is too windy to use a UAV for example)
  - Scenario creation allows for determining amount of such interdependencies
Theoretical Concepts for Experimentation

- **Task Structure - Multiple Paths and Degree of Uncertainty in SUMMIT**
  - MACRO-COG allows for manipulations of resources
    - Quantity and variety resources
      - Alter number of possible plans
      - Influence number of possible outcomes
    - Some resources are information resources
      - Each differing degrees of certainty (e.g., going to intel and weather roles)
      - Accessing information has different costs
Summary - Concepts for Experimentation

Experiment Thrust SUMMARY

A) Overarching concepts for macrocognition experiments
   - How do task factors alter macrocognitive processes?
   - How does distributed interaction influence differing elements of collaboration?
   - What is the impact of agent-based team members?

B) Metrics experimentation to support more diagnostic and construct valid understanding of macrocognition
Thank you
## Meta-Cognitive:
- individual understanding of problem conditions
- individual mental model development of situational significance

## Information Processing:
- problem identification
- understanding problem task
- establish team communication and trust
- establish data filtering methods
- establish meaning transfer conventions

## Knowledge Building:
- problem definition
- individual task knowledge
- individual team knowledge

### Communication Mechanism for Information Processing and Knowledge Building (applies to all stages):
- presenting individual information
- disagreement
- questioning

- discussing individual information
- negotiating perspectives
- discussion of possible solutions

- discussing team generated information
- providing rationale for individual solutions
- agreement

## Team Knowledge Base Construction

## Collaborative Team Problem Solving

## Team Consensus

## Outcome Evaluation and Revision

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### Problem Area Characteristics

#### Collaborative Situation Parameters:
- time pressure
- information/knowledge uncertainty
- dynamic information
- large amount of knowledge (cognitive overload)
- human-agent interface complexity

#### Team Types
- asynchronous
- distributed
- culturally diverse
- heterogeneous knowledge
- unique roles
- command structure (hierarchical vs. flat)
- rotating team members

#### Operational Tasks
- team decision making, COA selection
- develop shared understanding
- intelligence analysis (team data processing)

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### Collaboration Stages

#### Meta-Cognitive:
- goal development
- team mental model of problem
- team plan to solve problem

#### Information Processing:
- goal definition
- iterative information collection & analysis
- develop, rationalize, & visualize solution alternatives

#### Knowledge Building:
- team mental model of team
- team task knowledge
- domain expertise
- shared understanding
- collaborative knowledge

#### Collaboration Stages

- communicate goal requirements
- exit criteria?

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### STRUCTURAL MODEL OF TEAM COLLABORATION