Communication of Context in Multi-Echelon Information Exchange Environments

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Command 21 Research

Overall Goal: Enhance distributed multi-echelon knowledge exchange & command and control, via:

- The identification of problems inherent in such environments.
- Furthering our understanding of the process of information exchange
  - » Especially, the importance of shared task understanding
- Developing models and methods of knowledge transaction and tools to facilitate effective and efficient information exchange

Command 21 Program has many facets:

- Command Center design (and supporting tools and business rules)
- Knowledge Web, Knowledge Walls & Desks, and info production and knowledge management tools
- Exploratory and applied research toward improving information exchange, command & control, situation awareness, and decision making

Lessons Learned
(from previous Command 21 Efforts)

Knowledge Web (K-Web)

- Use at Global 2000 / 2001 War Games revealed that:
  » Mission goals, Commander's Intent, Commander's tasks and info requirements were not often shared effectively (and were not always understood by subordinates)
  » Multi-echelon aspects of these games highlighted disconnect between levels of command, and between joint and coalition partners
- Use onboard USS Carl Vinson (and others) confirmed issues:
  » Subordinate commands *that did not have K-Web* reported misunderstandings regarding Commander's Intent, Commander's tasks and info requirements, etc.
  » Much higher (and lower) echelons reported that K-Web content didn't always meet their needs

Fleet Interaction

- Past CTA's, observations, and ongoing interaction validate problems with sharing and shared understanding of context

Chat Survey

- Recent survey of fleet Chat users *(see related CCRTS paper and presentation)* revealed significant issues associated with sharing info in multi-echelon / multi-national environments

Information *producers* have access to information needed by information *consumers.* Their job – information production – is difficult, involving:

1. Determining which information is **relevant** and which is **not relevant** to the consumer's task and goals
2. Restating, reformatting, integrating **relevant** information, and ***adding value and creating new information*** to create a useful, useable information product.

This task is even more difficult in multi-echelon, multi-consumer environments

Information Producer

Information Consumer

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Effective and Efficient Information Exchange
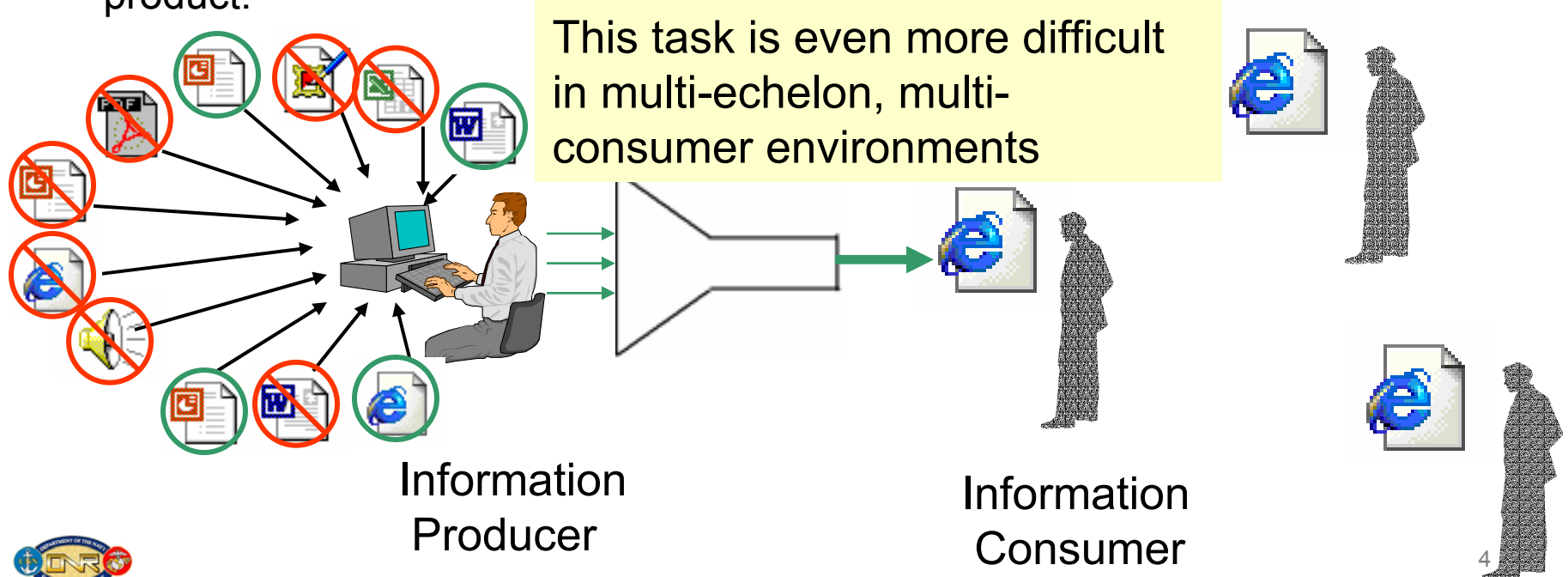
In all collaborative environments, optimal decision-making depends on information exchange being as effective and efficient as possible. We define these as:

- **Effective = the consumer gets all the information he needs to accomplish his tasks**
    - » **i.e., gets all the relevant information available**
- **Efficient = the consumer does *not* get any information that distracts him from his tasks**
    - » **i.e., does not gets any not relevant information**

Research Goals

Identify and develop strategies and tools to improve information exchange and overall situation awareness

Make information exchange as effective and efficient as possible.

Situation Context

Previous research underscores an important requirement, i.e., *Communication of Situation Context* in information exchange environments

- **Cognitive task analyses and evaluations**
- **Mental model literature**
- **Transactive memory literature**

Communication of Situation Context involves shared understanding of:

  » **Tasks and skills of team members**
  » **Information requirements of team members**
  » **Roles and role relationships**
  » **Information flow**
  » **Information sources and knowledge**

Research Questions

Obvious Hypothesis: Information exchange should improve if producers have more situation context - know more about consumers.

However, questions remain about what this information should be:

- What aspects of situation context are important?
- Are some types information about consumers more important than others?
- What happens when there are multiple consumers?
- Does consumer "status" affect information exchange?

Experimental Approach

To measure information exchange efficiency and effectiveness in an experimental setting we chose to examine producer performance at determining relevance of information based on what they understand about consumer

– **Our paradigm:**

» **Participants (producers) review information items**

» **Shown situation context & information about the consumer**

» **Given a realistic, limited amount of time to sort the items based on whether they believe items are:**

◆ **Relevant to the consumer → Efficiency**

◆ **Not relevant to the consumer → Effectiveness**

Metrics

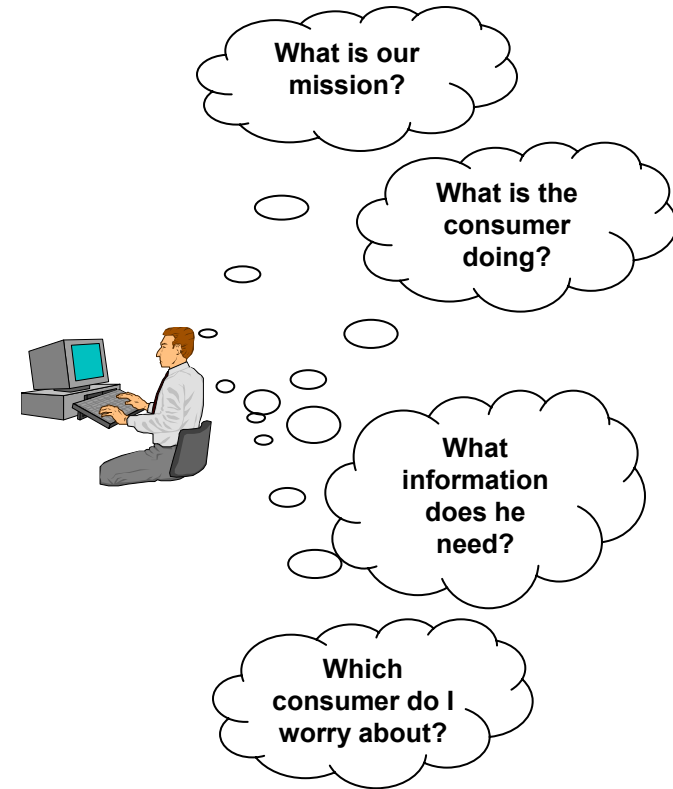**Signal Detection theory was used to measure performance:**

- **Use SMEs to determine relevance of information to consumers**
- **Measure degree of concordance between consumer and producer understanding of how relevant information is; for example:**
  - » **Hit: Producer and consumer both rate information as relevant**
  - » **False alarm: Producer rates information as relevant but Consumer rates it as not relevant**

Metrics, based on SME ratings:

- **Accuracy: Proportion correct**
- **Sensitivity (d'): Degree of overlap between producer / consumer understanding of information relevance**
  - » **Allows us to examine how well producer understands consumer's needs**
- **Response Bias (β): Tendency of producer to sort information as relevant or not relevant**
  - » **Allows us to examine biases towards effective and efficient information exchange**

Current Experiments

Two related experiments examined how to display situation context to producers
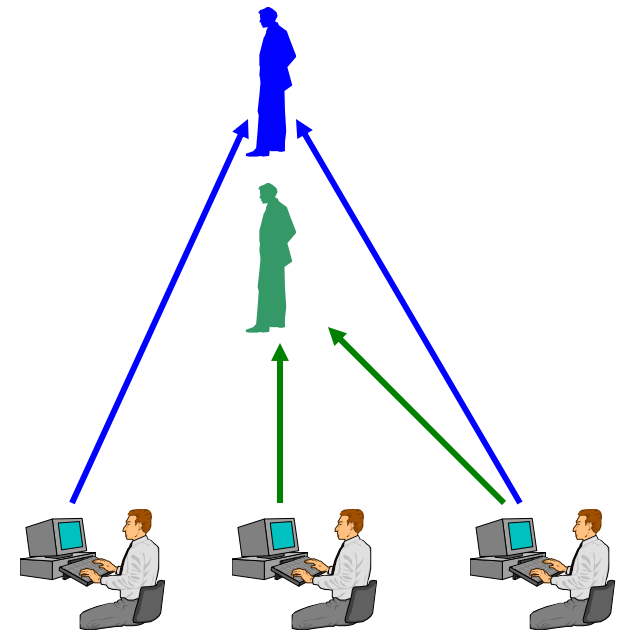
- *What* does the producer need to know about consumer(s)?
- What is the effect of tailoring information to a specific consumer?
    - » e.g., How useful is information created for consumer at one echelon to consumer at a different echelon.

What is our mission?

What is the consumer doing?

What information does he need?

Which consumer do I worry about?

Method

Participants played role of producer who sorted for either one of two, or both consumers in a multi-consumer organization.

- **"Highest" echelon = Commander, Joint Task Force (CJTF), consumer**
- **"Middle" echelon = Deputy Operations Officer (DOO), consumer**
- **"Lowest" echelon = producer (participant) creates products used by**

  - **CJTF**
  - **DOO**
  - **Both CJTF and DOO**

What we manipulated…

What does the producer need to know about consumer(s)?

- Participants sorted information related to Humanitarian Assistance – Disaster Relief scenario based on information we shared regarding:
  - » Mission only
  - » Mission + consumer's tasks
  - » Mission + consumer's information requirements
  - » Mission + consumer's tasks and information requirements
- Results allowed us to determine which aspects of situation context are most important to communicate to producers

What is the effect of tailoring information to a specific consumer or multiple consumers?

- In one experiment, participants sorted information for only one of the two consumers.

→ This allowed us to look at the cost to the *other* consumer if they needed to use the same information product

- In the other experiment, participants sorted information for only one of the two consumers, and then for both consumers (in a separate block / run / trial)

→ This allowed us to look at the how useful an information product created for multiple consumers was to each.
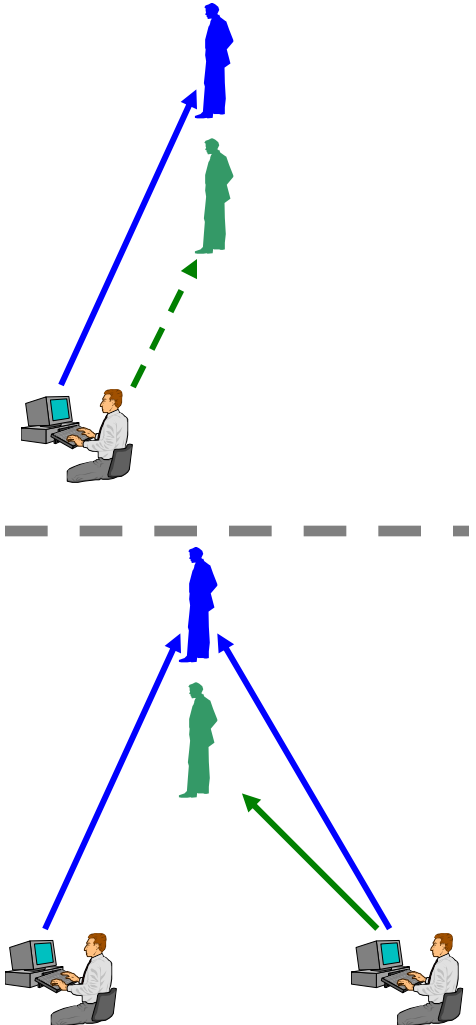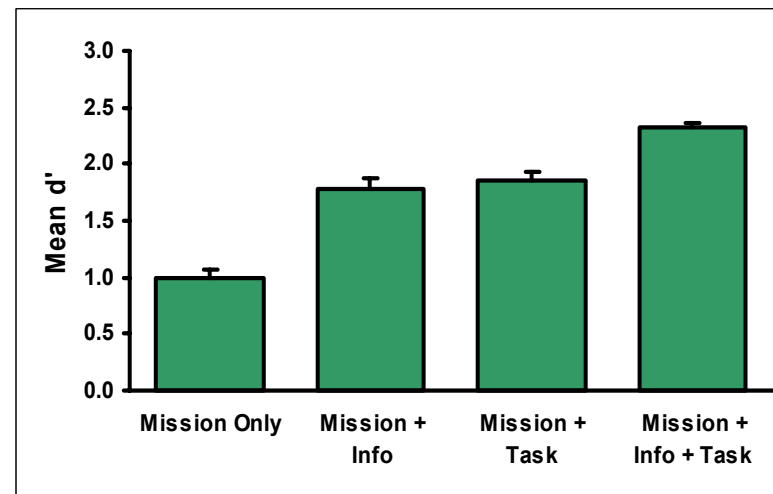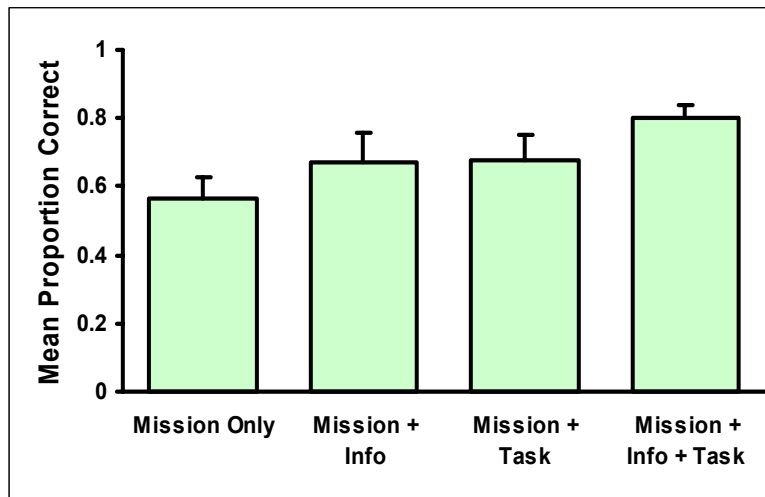
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Results

# Effectiveness of Information Exchange

Q: What aspects of situation context should be communicated to producers to improve effectiveness?

(Effectiveness = performance at sorting relevant info)

A: Highest accuracy and sensitivity when participants given *consumer task and information requirements*

Q: What aspects of situation context should be communicated to producers to improve efficiency?

(Efficiency = performance at sorting not relevant info)

A: Highest accuracy and sensitivity when participants given *consumer task and information requirements*
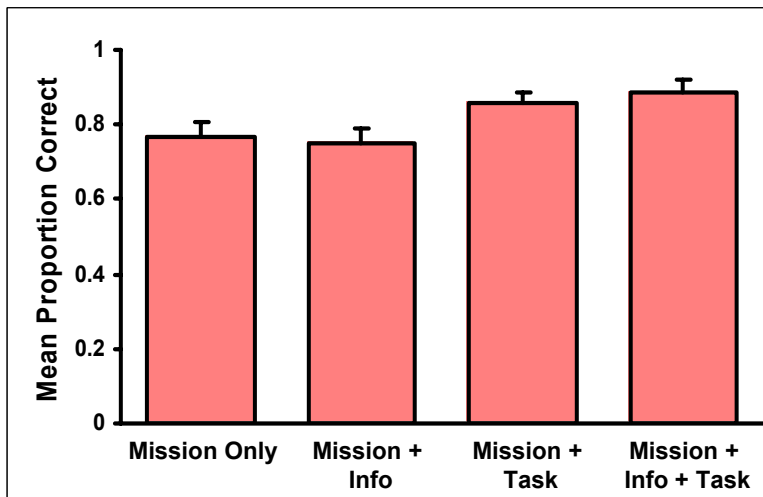
# What aspects of situation context should be communicated?

So far, results suggest….

- **Consumers' <u>mission</u>, <u>task</u>, and <u>information requirements</u> are all important and necessary aspects of situation context and therefore must be communicated to producers**
- **These results highlight the importance of maintaining a shared situation context**

No real surprises here…

But the real world is not so simple…

What about in multi-consumer situations?
(which are the norm…)

– **When participants sorted for one specific consumer**

  » There was a cost when other consumers, *with different tasks and requirements*, are required to use information products produced for someone else

  » Especially with respect to *effectiveness* of information exchange

  » The more **relevant** the information was for one consumer, the more **not relevant** it often was for other consumers…
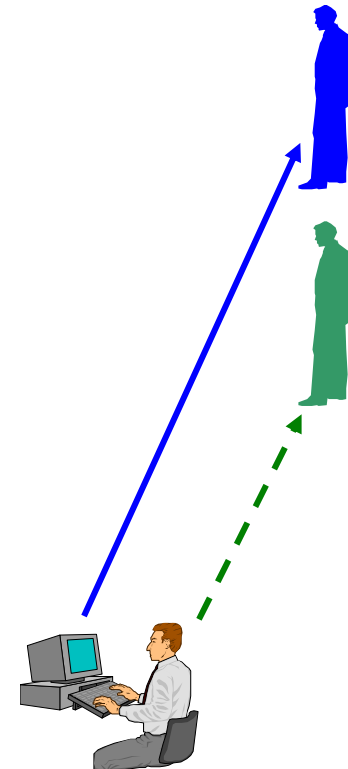
When participants sorted *for both consumers*

- **There was a bias in selecting information to share**
  - » **Producers erred on the side of providing too much information rather than risk not providing enough**
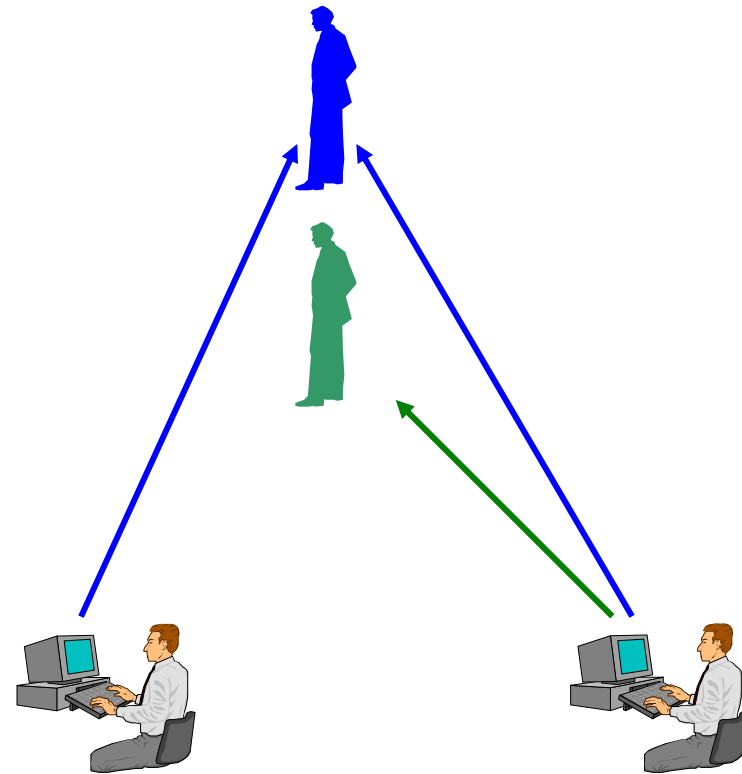
Does consumer "status" affect information exchange?

There was a bias towards meeting needs of higher-level consumer

– **Overall performance was lower when participant was required to sort for two consumers (even if one was of higher status)**

– **Overall performance was better when CJTF was the only consumer (users worked harder – were more effective and efficient – when someone of very high rank was their only customer)**

Conclusions

To make information producers more effective and efficient:

- **Explicitly communicate mission, task, and information requirements**
- **Include information about all potential consumers**
  - » **Difficult to implement when number of consumers is large…**
- **Recognize bias towards consumers with higher status**
  - » **Develop and follow business rules to moderate**
- **Incorporate other aspects of situation context in situation context displays**
  - » **Future research will examine effects of changes to the situation**

Early Application of Results

These results have led to:

- **New business rules and recommendations**

- **Development of a prototype *Consumer Information Requirements Display Tool* (templates) to support information exchange in multi-echelon environments**

  » **Demonstrated at MECC Lab (at Naval Postgraduate School) using SMEs in a multi-echelon, distributed teams environment performing a mission that required extensive information sharing**

  » **Based on this applied work…** (See next slide)

Notional Situation Context Display

Mission: Conduct Humanitarian Assistance and Disaster Relief operations. Our primary goals are:
- Coordinate with Philippine government / coalition partners.
- Evacuate population from areas threatened by violence.
- Provide security assistance to the current Philippine government.
- Maintain status quo with regard to insurgent activities.

Team

Battle Watch Captain
- MetOc
- Tactical Watch Officer
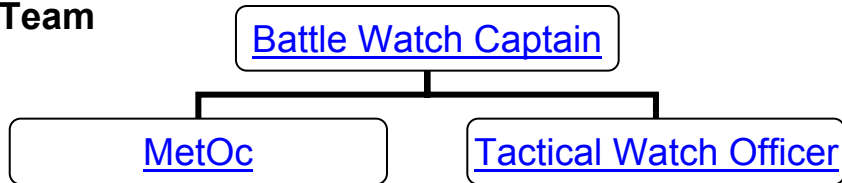
Team Lead: Feedback and Information
My Tasks
- Develop and maintain Situation Awareness relevant to the planned evacuation of refuges.
- ◆ CJTF has identified Siquijor as evacuation site.

My Information Requirements
- Known or suspected rebel units and activities.
- Christian refugees.
- Evacuation resources and activities.
- ◆ Siquijor conditions and facilities.

Feedback
- [Posted 12/22/03 0903] Team members, please provide me with more information about that rebel aircraft we spotted

Questions?