U.S. Army Research, Development and Engineering Command

Effects of Communication Delays on Distributed Team Interaction

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

Andrea Krausman
U.S. Army Research Laboratory

ICCRTS 2013

PUBLIC RELEASE DISTRIBUTION UNLIMITED

Introduction

- Communication is essential for team performance
  - Involves active, timely exchange of information between team members
    - Task, team relevant information
    - Progress, errors, feedback
  - Communication underpins all other teamwork components (Dickinson & McIntyre, 1997)
    - Shared understanding
    - Interpersonal trust
      - Critical enablers of distributed team collaboration (Peters & Manz, 2007; Cohen & Gibson, 2003)
  - Communication breakdowns can be serious
    - Aircraft incidents, medical errors, fratricide

Introduction

- Communication delays
  - Salient problem in distributed operations
    - Network parameters
      - Bandwidth
      - Distance between nodes
      - Traffic level
    - Organizational protocol
      - Black Hawk Down

- Depending on the situation, communication delays may range from relatively imperceptible (cell phone conversations), to rather extensive such as delays that occur during space missions.

Background

- Communication delays are real problems in operational environments:
  - Delays from Earth to Mars: 2 minutes to 22 minutes
  - Field experiment at Fort Dix (2009)
    - Delays ranged from 0.16 seconds to 1.8 seconds
      - Bowman & Zimmerman (2010)
  - Afghanistan (Soldier interview)
    - Blue force tracking (BFT) text message delays of up to 10 minutes
      - Routing issue
  - Subject matter expert (SME) interviews suggest delay categories:
    - Low delays: <500 msec (single hop)
    - Medium delays: 500 -1500 msec (multi hop)
    - High delays: >1500 msec (satellite)

Background

- Empirical Work
  - Delay lengths and human performance
    - below 300 msec pose some impact on conversations
    - 450 – 700 msec noticeable impact on conversations and task performance
    - > 700 msec drastic impact on conversations and task performance
- Communication delays:
  - Disrupt turn taking, create overlaps and hinder timely feedback
  - Impede task performance
  - May be responsible for user anxiety/uneasiness

Research Questions

- What effect do communication delays have on trust, shared understanding, information exchange, satisfaction, and mental workload?

- What effect does a video channel have on trust, shared understanding, information exchange, satisfaction, and mental workload when team member communication is delayed?

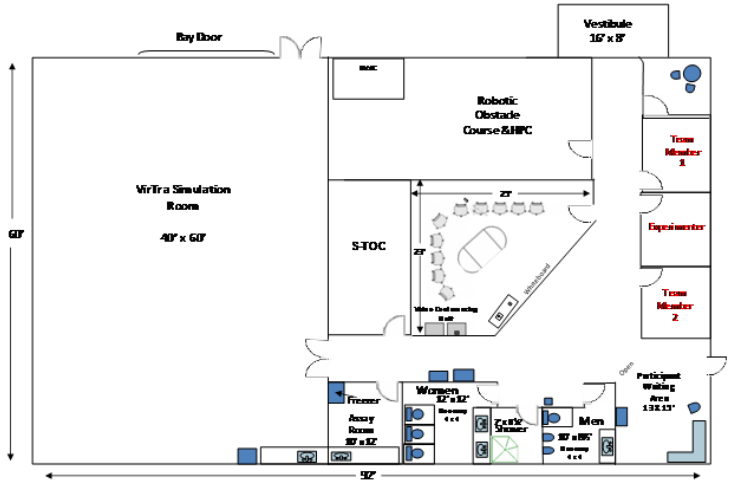
Communication delay defined:
Duration of time it takes for the listener to hear the speaker's voice.

Hypotheses

1. Increases in delay length will result in lower shared understanding, less information shared, lower team satisfaction and trust scores.
2. Increases in delay length will result in increases in task completion time and mental workload.
3. Audiovisual technology will moderate the effect of communication delays such that shared understanding will be higher, more information will be exchanged, and team member satisfaction and trust scores will be higher than audio alone.
4. Audiovisual technology will moderate the effect of communication delays such that task completion time and mental workload will be lower than with audio only.

Proposed Research

- Laboratory study – CASEL experimental chambers
- Participants
  - 72 (36 dyads)
  - Civilian employees at APG
    - Not compensated
  - Temporary employment agency
    - Compensated by agency: $17/hr
- Dyads
  - Distributed (located in different chambers)
  - Same throughout experiment
  - Half familiar with each other
    - Worked on a project together?
  - Same and mixed-gender
    - 12-MM, 12-FF, 12-MF



Equipment

- Experimental chambers:
  - Dell desktop computer
  - 22” LCD monitor, keyboard

  - Communication Technologies
    - Audio environment
      - Headset, microphone
      - Audacity/Audition audio software
      - Ulead software for recording

    - Audiovisual environment
      - Headset, microphone
      - Audacity/Audition audio software
      - Ulead software for recording
      - Video camera

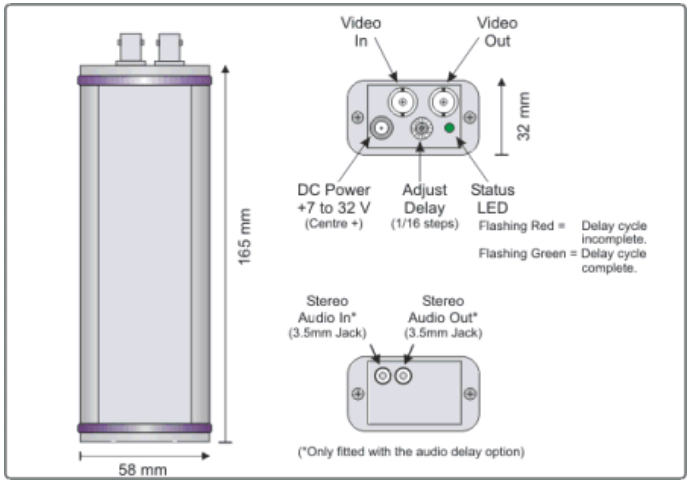
Equipment

- Experimental task – Experimental Laboratory for Investigating Collaboration, Information Sharing, and Trust (ELICIT).
  - Computer-based multiplayer intelligence game
    - Team members "play" role of intelligence analysts
  - Team members receive factoids on computer display
    - Factoids contain information about a fictitious terror plot
  - Team goal: collaborate and share factoids to identify who, what, where, and when of terror plot

Who factoid	The orange group is not involved
What factoid	A new train station is being built in Alphaland
Where factoid	The brown, pink, and blue groups have the capacity to attack targets in Alphaland, Betaland, & Omegaland
When factoid	The brown group prefers to attack in daylight

Equipment

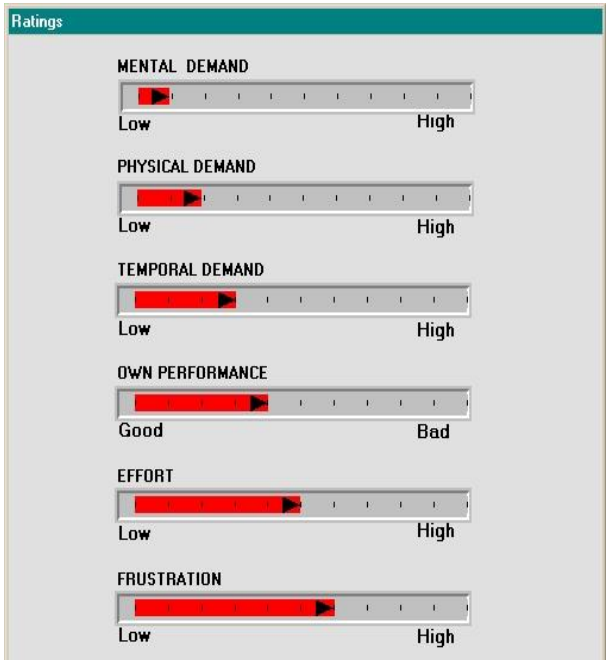
- Delay technology
  - DelayLine Audio/Video delay device (Allen Avionics)
    - Supports delays from 0 – 3.2 seconds in 200 msec intervals



  - Delays of 400, 800, and 1600 msec used in current study

Methods

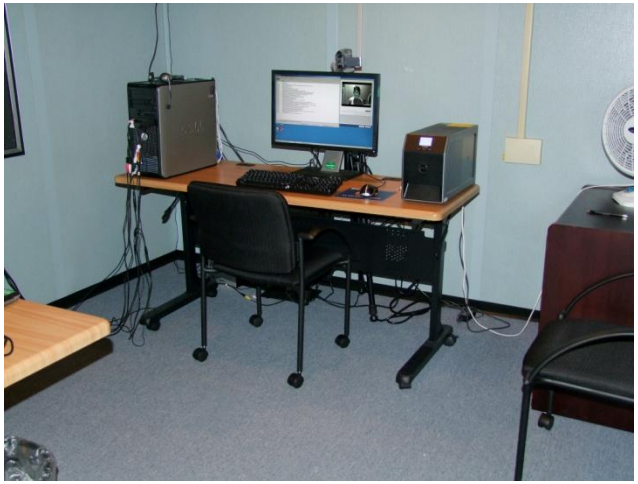
- 2 x 3 Within-subjects design
  - Independent Variables:
    - Technology (Audio, Audiovisual)
    - Delay length (msec): 400, 800, 1600
      - low, medium, high categories
  - Balanced Latin Square
- Dependent variables:
  - Task completion time (logged in ELICIT)
  - Shared understanding (ELICIT accuracy)
    - Accuracy = (1 + 1 + 1 + 1/3) / 4 = 0.83
  - Percentage of factoids shared
  - Interpersonal trust: McAllister's trust scale
  - Trust in technology
  - Satisfaction (van der Kleij, 2007)
  - Workload: NASA TLX



NASA TLX Workload Scale

Procedures

- Pre-experiment procedures
  - Participants seated in different rooms in CASEL
  - Informed consent
  - Demographic and computer experience survey
  - ELICIT training session
    - Dyads perform ELICIT training
    - Audio or audio-visual technology
    - No delay
  - 5-minute break



Procedures

- Experimental procedures
  - Team members seated in different chambers in CASEL
  - Team performs ELICIT task:
    - Team members receive 34 random factoids
      - Two waves: Start of trial, 5 minutes
      - Verbally share and discuss factoids using audio and audiovisual technology.
    - Team enters proposed solution in ELICIT software
      - Who, what, where, when
      - Time pressure
  - Surveys administered
  - 5-minute break
  - Team performs six sessions of ELICIT total (2.5 hours)
  - After final session - short debriefing session

Data Analysis

- Team performance data (task completion time, shared understanding, percentage of factoids shared)
  - Repeated measures ANOVA
  - α = .05
  - Tukey's Honestly Significant Difference (HSD) post hoc test

- Subjective data measured will be averaged and treated as interval data for analysis
  - Repeated measures ANOVA
  - α = .05
  - Tukey's Honestly Significant Difference (HSD) post hoc test

- Supplemental analysis of team composition and familiarity data will help inform follow-on study.

Summary

- Study responds to the need to study factors affecting distributed communication by investigating how communication delays impact team processes and information sharing.
- Results used to inform work system and/or distributed team design as well as provide insight into interventions that may counteract performance degradations caused by communication delays.
  - task redesign, interface design, team training
- Enable organizations to fully utilize the flexibility that distributed arrangements provide without compromising team effectiveness.

Questions?