INSTANT MESSAGING AND TEAM PERFORMANCE IN A SIMULATED COMMAND AND CONTROL ENVIRONMENT

21 June 06

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<table>
<thead>
<tr>
<th>1. REPORT DATE</th>
<th>JUN 2006</th>
<th>2. REPORT TYPE</th>
<th>3. DATES COVERED</th>
<th>00-00-2006 to 00-00-2006</th>
</tr>
</thead>
<tbody>
<tr>
<td>4. TITLE AND SUBTITLE</td>
<td>Instant Messaging and Team Performance in a Simulated Command and Control Environment (Briefing Charts)</td>
<td>5a. CONTRACT NUMBER</td>
<td>5b. GRANT NUMBER</td>
<td>5c. PROGRAM ELEMENT NUMBER</td>
</tr>
<tr>
<td>6. AUTHOR(S)</td>
<td></td>
<td>5d. PROJECT NUMBER</td>
<td>5e. TASK NUMBER</td>
<td>5f. WORK UNIT NUMBER</td>
</tr>
<tr>
<td>7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)</td>
<td>Air Force Research Laboratory, Wright Patterson AFB, OH, 45433</td>
<td>8. PERFORMING ORGANIZATION REPORT NUMBER</td>
<td></td>
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<tr>
<td>9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)</td>
<td></td>
<td>10. SPONSOR/MONITOR’S ACRONYM(S)</td>
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<tr>
<td>12. DISTRIBUTION/AVAILABILITY STATEMENT</td>
<td>Approved for public release; distribution unlimited</td>
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<td>13. SUPPLEMENTARY NOTES</td>
<td>The original document contains color images.</td>
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<td>14. ABSTRACT</td>
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<td>15. SUBJECT TERMS</td>
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<tr>
<td>16. SECURITY CLASSIFICATION OF:</td>
<td>a. REPORT</td>
<td>unclassified</td>
<td>b. ABSTRACT</td>
<td>unclassified</td>
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<td>17. LIMITATION OF ABSTRACT</td>
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<td>19a. NAME OF RESPONSIBLE PERSON</td>
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Collaboration Technologies and Command and Control (C2)

- Recent military acquisitions emphasize introducing collaboration technologies into C2 environments (Kaufman, 2005)
- Personnel are expected to rapidly coalesce into functioning teams (Boiney, 2005)
- Performance may be facilitated through emerging collaborative technologies (i.e., email, IM, virtual whiteboards, videoconferencing, etc.) (e.g., Alberts & Hayes, 2003)
Potential Problems with Collaboration Technologies

• Bordia (1997): Literature synthesis
• Baltes et al. (2002): Meta-analysis

• Concluded that teams restricted to text-based collaboration technologies:
  – Made poorer decisions
  – Took more time to reach a decision
  – Experienced less satisfaction with team processes
  – Pattern of results was observed across different experimental tasks
  – Bordia (1997): Restricted communication impairs team comprehension
Task Type and Collaboration Technologies

- Using McGrath’s (1984) circumplex model, team experiments can be categorized by task type.

- Studies reviewed by Bordia (1997) & Baltes et al. (2002) are primarily choosing tasks.
  - Require problem solving in situations with and without correct answers.
  - Generally, task is completed when the team achieves a consensus.
C2 tasks are better described as *execution* tasks (McGrath, 1984)

- Involve competition (both inter- and intra-team) or performance measured against a standard of excellence
- Team performance dependent upon in-team performance and opposing-team performance
- Generally, task completion criterion are different
Goals and Hypotheses

• Goal for the study was to evaluate the potential utility of instant messaging (IM) and to examine its effects on team performance in an *execution* task (RoboFlag)

• Hypotheses:
  - Communication restricted to IM would result in lower mission success rates, longer mission completion times, and less coordinated team strategies
  - Restricted communication would result in higher workload and lower situational awareness
  - Teams restricted to IM would send more instant messages than teams whose communication was unrestricted
Method

• Participants
  – 36 paid participants (28 men, 8 women)
  – Participants completed experiment in groups of four, yielding a total of nine experimental groups

• Experimental design
  – 2 × 3 within-subjects design
  – Control environment (remote, co-located)
  – Level of abstraction (manual, automated, mixed)*
Method

• Participants completed six mission trials in each condition (36 trials total).

• Control environment was a block factor (12 trials per block), and level of abstraction was randomized within each block.

• Participants filled out the NASA-TLX and one item from the 3-D SART following each mission trial.
RoboFlag Simulated Environment

<table>
<thead>
<tr>
<th>ROBOT ID</th>
<th>STATE</th>
<th>TYPE</th>
<th>PLAY</th>
<th>FUEL</th>
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<td>ACTIVE</td>
<td>CIRCLE</td>
<td>Destination</td>
<td>20.2</td>
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<td>Robot 2</td>
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<td>CIRCLE</td>
<td>Destination</td>
<td>20.4</td>
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<tr>
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<td>FLAGGED</td>
<td>CIRCLE</td>
<td>Circle Offense</td>
<td>25.9</td>
</tr>
<tr>
<td>Robot 4</td>
<td>ACTIVE</td>
<td>TRIANGLE</td>
<td>Guard Position</td>
<td>3.8</td>
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<td>Robot 5</td>
<td>ACTIVE</td>
<td>TRIANGLE</td>
<td>Guard Position</td>
<td>5.8</td>
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<td>Robot 6</td>
<td>ACTIVE</td>
<td>TRIANGLE</td>
<td>Guard Position</td>
<td>15.9</td>
</tr>
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</table>
Method

• Participants given written and verbal instructions on the capabilities of circles & triangles

• Participants told that experiment involved a game similar to ‘capture the flag’
  — Each team was in direct competition with the other

• Any single trial continued until one team successfully captured the other team’s flag
Method

• Participants allowed to practice for five minutes
  — Option of additional practice time if needed

• Prior to the start of each mission trial, participants were allotted 30 seconds for communication (30 second “huddle”)
• RoboFlag software recorded which team successfully captured the flag (the winner) and the time elapsed during each mission trial.
  – Also recorded the number of vehicle position changes initiated by each participant
• Analysis strategy: Follow the Winner
Results

• Data for each factor tested for statistical significance by means of a 2 (control environment) × 3 (level of abstraction) repeated measures analysis of variance (ANOVA)

• For the frequency of wins, mission length, and number of vehicle position changes no statistically significant differences were detected between the two conditions ($F [1, 8] = 0.22, 0.49, 0.45$ respectively, $p > .05$).
Results

• One possible explanation for the results was that one team consistently won all mission trials (i.e., teams were unevenly matched – team 1 vs. team 2 distinction).

• The number of mission trials each team won was counted and compared by means of a two-sample t-test.

• Result indicated that there was not a significant difference for number of wins, $t (16) = 0.73, p > .05$. 
Results

• Data were also examined to identify patterns of wins that were not due to the experimentally manipulated factors.
  – Defined a win ‘streak’ as three or more serial wins by the same team
  – A total of 38 win streaks were identified in the data

• Mean number of win streaks per experimental session per team was 2.11 ($SE = 0.32$)

• Mean number of trials in a streak was 4.05 ($SE = 0.45$)
  – Neither was statistically significantly different
Results

• Tested the effects of the experimental conditions on participants’ workload and situational awareness ratings by means of a 2 (control environment) × 3 (level of abstraction) repeated measures ANOVA.

• For workload and situational awareness, no statistically significant differences were detected between the remote and co-located conditions (\(F[1, 35] = 0.30, 0.00\) respectively, \(p > .05\)).
Results

• From IM logs, total number of communications per experimental session was calculated.

• Messages were divided into three categories, depending on when they were sent:
  – Pre-game messages
  – In-game messages
  – Post-game messages
Results

• IM’s sent between teammates were analyzed to determine content.

• Messages were coded as either ‘irrelevant’ (e.g., “I’m hungry,” “I like this game”) or ‘strategy-relevant’ (e.g., “go straight for their flag,” “use more robots next time”).

• Two coders separately classified each instant message into one of the two categories.
  – Inter-coder reliability was good ($Kappa = 0.92$).
Results

• Mean number of strategy-relevant and irrelevant instant messages sent during each messaging period for both command environments were compared using a 2 (type of message) × 3 (messaging period) × 2 (command environment) repeated measures ANOVA.
Results

The diagram illustrates the mean number of instant messages sent under different conditions:

- **Strategy-Relevant**
- **Irrelevant**

For each condition (Co-Located, Remote), the diagram separates the data into:

- **Pre-Game**
- **In-Game**
- **Post-Game**

The bars show the mean number of messages sent with error bars indicating variability.
Discussion

• Previously hypothesized that:
  
  – Communication restricted to IM would result in lower mission success rates, longer mission completion times, and less coordinated team strategies
  
  – Restricted communication would result in higher workload and lower situational awareness
  
  – Teams restricted to IM would send more instant messages than teams whose communication was unrestricted
Discussion

• Overall, IM did not affect team performance.
• Contrasts the effects of collaboration technologies reported by Bordia (1997) and Baltes et al. (2002)
• Dynamic, adversarial nature of execution tasks may favor:
  – Succinct messages between teammates
  – Weak or generalized strategies
  – Feedback may engender dynamic strategy evolution
    • Supported by infrequent win streaks
    • May explain high ratio of irrelevant to strategy-relevant messages
Discussion

• IM also did not negatively impact workload and situational awareness
  – Temporal demands favor short communications and focused attention
  – Also, competition and game-related nature of the RoboFlag environment may motivate participation (Matthews & Westerman, 1994)
Discussion

• Participants were using IM for collaboration
• However, participants largely used IM for socialization purposes, rather than using it exclusively for strategy development and coordination.
• May be some concern on longer tasks, particularly if they require less active involvement
  – Potential for personnel to engage in off-task conversations more frequently, resulting in distraction, decreased situational awareness, and ultimately poor team performance.
Discussion

• Current experiment offers limited support for future successful integration of collaboration technologies into command and control environments

• Team performance unchanged under both command environments, indicating that IM was at least as effective as face-to-face collaboration

• Results underscore need for continued research into team performance and collaboration technologies in tasks from the executing quadrant of McGrath’s (1984) circumplex model
Discussion

• Potential foci for future research:
  – Track strategy development, implementation, and execution
  – Factors that mediate the use and performance consequences of collaborative tools (i.e., task workload, time on task, etc.)
Questions?