Power to the Edge...
Also under Threat?

Wim Kamphuis, PhD
TNO Human Factors, NLD

15th International Command and Control Research and Technology Symposium
June 22-24, 2010 - Santa Monica, CA
Ambush in Iraq

- Large scale ambush rather than small scale hit-and-run attack
- Company command orders QRF to drive straight into large-scale ambush
  - Adherence to initial hypothesis (small scale)
  - Fitting in of conflicting information
- Company command denies valuable assistance from battalion
  - Drive to stay in control
  - Keeping off interference of others
Threat-Rigidity Thesis (Staw, Sandelands, & Dutton, 1981)

- Restriction in Information processing
  - Narrowed field of attention
  - Fewer alternatives considered
  - Reliance upon prior hypotheses

- Constriction in control
  - Leaders tightening the reins
  - Centralization of authority
  - Fewer people making decisions

- Stability & predictability environment

- Effectiveness
  (Individual-Team-Organizational)
C2 Approach Space

In more capable C2 approaches:

- Decision rights are more broadly allocated to the collective;
- Interaction patterns among entities are less constrained;
- Information is more broadly distributed among entities;

leading to higher levels of shared awareness and understanding and increased effectiveness
However…

- The hypothesized effects of threat diametrically oppose the more capable positions on the dimensions of the C2 Approach Space:

  - Constriction in control
  - Restriction in information processing
  - Broad allocation of decision rights
  - Unconstrained patterns of interaction

  - Broad information distribution
Research Question

In theory, effects of threat may be detrimental to more capable C2 approaches

- What exactly are the effects of threat on teams during complex tasks? (study 1)
- What can be done to stop threat from negatively affecting teams? (study 2)
Research methodology - Prior research

**Goal:** Controlled experimental research on team performance in *complex environments*

- **Simple team tasks**
  (Winter Survival Exercise, Decide which of two patterns contains more white, etc.)
  - Highly controllable
  - Lack of interdependence, team processes, and complexity

- **High-fidelity simulations**
  (Management simulations (Tycoon), flight simulators, etc.)
  - Real team behavior, highly complex
  - Little experimental control

- **Tactical team tasks**
  (TANDEM, DDD, TIDE², C3FIRE, etc.)
  - Real team behavior, good degree of control
  - Focus on *action aspects* of performance (*rule-based*), no higher-level, non-routine, problem-solving processes demanded
Creating a New Research Environment

- Development of a research environment for controlled experimental research on team performance in complex environments

- Requirements:
  - Real team behavior
  - Complex tasks
  - Experimental control
  - Efficient data collection
  - Broad range of measurement possibilities (real-time, automated behavioral measures and online embedded questionnaires)
  - High flexibility
What is PLATT?

- A flexible software platform for experimental team research

- Two components:
  - Modular software architecture *(JADE agent platform)*
  - Research-specific scenarios

- Software architecture is research question independent and guarantees large degree of flexibility

- Scenario development is driven by research question and based on research model
PLATT – Software architecture

- **Scenario Player** sends scenario events
- Scenario Player controls access and updating of web pages on **Web Agent**
- Participant uses **Participant Interface** to:
  - Process scenario events
  - Requests web pages
  - Interact with shared workspace
  - Interact with other participants
PLATT – Software architecture

- Different participant applications can be plugged into the framework:
  - Every component loads on a new tab in participant interface
  - Different communication media (e-mail/ video-conferencing/ chat)
  - Different shared workspaces (COP/ postings board/ whiteboard)

- Many configurable variables, e.g.:
  - Communication structure of team (or teams)
  - Interface components participants receive
  - Information access rights
PLATT – Scenarios

- Scenarios are research-question specific. So far:
  - Military planning
  - Crisis management
  - Collaborative decision-making

- Scenarios are written in Excel by defining events on a linear timeline
  - Write own scenarios
  - Adjust existing scenarios

An event can have various types of content:
  - **Text** (e-mail messages)
  - **Audio** (voice-mails, telephone calls, radio broadcasts)
  - **Video** (news broadcasts, surveillance cameras, etc.)
  - **Updates** of web pages
  - **Hyperlinks** (to internal web server or online questionnaires)
## PLATT – Excerpt of scenario file

<table>
<thead>
<tr>
<th>Time</th>
<th>Sender</th>
<th>Recipient</th>
<th>Subject</th>
<th>Message</th>
<th>Hyperlink</th>
</tr>
</thead>
<tbody>
<tr>
<td>00.10.30</td>
<td>Local civilians</td>
<td>Intelligence</td>
<td>Information: Rebels in the west</td>
<td>Today, our cousin travelled from Iskra to Golesh. At the river, he was shot at by a sniper. He barely managed to escape. It is advisable to avoid this road.</td>
<td></td>
</tr>
<tr>
<td>00.11.00</td>
<td>Patrol</td>
<td>Intelligence</td>
<td>Information: Rocket launchers</td>
<td>At the northern part of the road between Debrashtsa and Ustrem, we observed a Group of 20 rebels, some of which were carrying rocket launchers. If you want to make use of this road for the evacuation, you will need to plan a deployment of the infantry unit to clear this part of the route.</td>
<td></td>
</tr>
<tr>
<td>00.11.00</td>
<td>Local Radio Station</td>
<td>Logistics</td>
<td>Weather Report</td>
<td>In the north, heavy snowfall occurred in the mountains. As a consequence, some roads may have become obstructed. At this moment, more accurate information can not be provided.</td>
<td></td>
</tr>
<tr>
<td>00.11.00</td>
<td>Home Operations</td>
<td>Home</td>
<td>Everything ok</td>
<td>Hi there! How are you? Here everything is all right. We hope to hear from you soon…</td>
<td></td>
</tr>
<tr>
<td>00.12.00</td>
<td>Intelligence</td>
<td></td>
<td></td>
<td></td>
<td>roads/RoadLG_2.htm</td>
</tr>
<tr>
<td>00.12.30</td>
<td>Transportation unit</td>
<td>Logistics</td>
<td>Information: Loss of vehicle</td>
<td>One of our transportation vehicles broke down. Sadly, it is not possible to repair this vehicle.</td>
<td></td>
</tr>
<tr>
<td>00.13.00</td>
<td>Intelligence</td>
<td></td>
<td></td>
<td></td>
<td>roads/RoadIG_2.htm</td>
</tr>
<tr>
<td>00.13.30</td>
<td>Local Radio Station</td>
<td>Intelligence</td>
<td>Newsflash: Demonstration</td>
<td>On the road between Kriva Bara and Popints, a large crowd demands president Tsankov’s resignation. For the time being, the demonstration is peaceful. However, motorists making use of this road should already expect a delay of 45 minutes.</td>
<td></td>
</tr>
<tr>
<td>00.13.30</td>
<td>Patrol</td>
<td>Logistics</td>
<td>Information: Pass taken</td>
<td>The pass between Ustrem and Straro Selo that seemed to have been taken by the rebels, proves to be entirely safe.</td>
<td></td>
</tr>
<tr>
<td>00.14.00</td>
<td>Local civilians</td>
<td>Intelligence</td>
<td>Information: Rebels in the east</td>
<td>In the east, between Debrashtsa and Bogydants, rebels have been spotted. This road seems not to be safe anymore.</td>
<td>roads/LRoadUP_2.htm</td>
</tr>
<tr>
<td>00.14.00</td>
<td>Logistics</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>00.14.00</td>
<td>All</td>
<td>- Questionnaire-</td>
<td></td>
<td></td>
<td><a href="http://tmquest.tm.tno.nl/">http://tmquest.tm.tno.nl/</a>~</td>
</tr>
</tbody>
</table>
PLATT – Measures

- **Behavioral data**
  - All actions automatically logged in log file
    - Real-time unobtrusive measures
    - Analysis supported by Data Analysis Tool

- **Self-report data**
  - Online embedded questionnaires
    - Integrated in scenario, sent at specific time
    - Real-time measurement of processes and cognitions

- **Outcome measures**
  - Scenario-specific
PLATT – Summary

- PLATT allows:
  - Integration of complexity while maintaining experimental control
  - Real-time behavioral measures
  - High degree of flexibility
  - High degree of realism
  - Wide range of research questions
  - Modifications by researcher
  - Unlimited number of participants and teams

- Suitable research environment for C2 experimentation relating to:
  - Complex endeavors
  - Networked collaboration
  - Comprehensive approach
  - Multi Team Systems
Study 1

The Effects of Physical Threat on Team Processes During Complex Task Performance
Theory & Hypotheses

- Few prior studies

- Threat-rigidity thesis (Staw et al., 1981):
  - Restriction in information processing (e.g., Gladstein & Reilly, 1985)
  - Constriction in control (e.g., Argote et al., 1989)
  - Narrowing of team perspective (Driskell et al., 1999; Ellis 2006)
Method – Design

- 81 participants (civilians)
- 26 three-person teams
- Complex scenario in PLATT: military evacuation scenario
- 1 factor: physical threat

Between teams design:
  - Physical threat (13 teams)
  - No physical threat (13 teams)
Method – Military evacuation scenario

- **Assignment:**
  Make plan to extract group of people from hostile area

- **Three roles**, with unique knowledge, expertise and responsibilities:
  - S2 – Intelligence (safety and reliability)
  - S3 – Operations (leader, coordinating and directing)
  - S4 – Logistics (personnel, materiel, condition and length of roads)

- **Events** *(messages coming from different sources):*
  - Enemy activities
  - Road conditions
  - Delays
  - Weather reports
  - Home front events
  - Personnel problems
  - Materiel problems
  - Local unrelated events
Method

Extra informatie over wegen

Op deze webpagina vind je voor iedere weg in het gebied een link. Via deze links kan je voor jouw rol belangrijke informatie vinden over de betreffende wegen. De informatie die je via deze website krijgt is altijd betrouwbaar.

Let op!

Als er over een weg geen aansluitende informatie beschikbaar is via de link, wil dat niet zeggen dat er niks aan de hand is op dat wegdeel!

Niet alle informatie die beschikbaar is, komt namelijk op deze webpagina aan. Er kan alleen informatie op de site komen te staan als je over een bepaalde weg een bericht hebt gekregen van een bron die niet betrouwbaar is.

Naar aanleiding van een dergelijk bericht heb je extra informatie nodig over de betreffende weg. De links zijn een belangrijk hulpmiddel om extra informatie te krijgen. De informatie die je in deze lijst kunt vinden is dus altijd aansluitende informatie (net als de berichten van een andere bron, hetgeen de onbetrouwbaarheid van die bron opheft).

Als je informatie van een betrouwbare bron over een weg hebt gekregen, dan heb je volgend aan die informatie, er komt dan niet ook nog een bericht op de site van de betreffende weg te staan.

De informatie over de wegen verandert gedurende de taakvoering. De websites worden namelijk bijgewerkt wanneer er nieuwe informatie beschikbaar is.

Als je op zo'n link staat, en je nog meer betrouwbare informatie zocht, dan worden de pagina’s opnieuw bijgewerkt zijn! Vergeet dus maar niet te refresh!

Weginformatie

Afgered – Chimeno
Afgered – Gikara
Afgered – Opper
Chimeno – Opper
Chimeno – Dikabba
Chimeno – Ikira
Chimeno – Njikora
Chimeno – Njikora
Chimeno – Opper
Chimeno – Opper

Grikor – Ikira
Grikor – Ustima
Grikor – Njikora
Grikor – Opper
Grikor – Njikora
Grikor – Opper
Grikor – Opper
Grikor – Opper
Grikor – Opper
Grikor – Opper

Ikira – Njikora
Ikira – Opper
Ikira – Eroka
Ikira – Eroka
Ikira – Njikora
Ikira – Opper
Ikira – Opper
Ikira – Opper
Ikira – Opper
Ikira – Opper

S4
S3
S2

SCENARIO/WEB SERVER

SHARED WORKSPACE
Method – Physical threat manipulation

Supposed ‘Team performance at high altitudes’-study*

- Climatic chamber
- Reduced oxygen level
- Simulated height up to 6000 meters (almost 20,000 feet)

- Side-effects explained by physician
  - Respiratory problems
  - Headaches
  - Heart palpitations
  - Throwing up
  - Fainting

- In reality, nothing happened!

*Approved by ethical review board
Method – Measures

- **Information processing**
  - Attention to relevant ‘hidden’ information (logging of opening of messages)
  - Degree of overview (self-report)

- **Degree of control**
  - Leadership control (self-report)
  - Participative leadership (self-report)
  - Amount of deliberation (content of e-mails)

- **Collaboration**
  - Coordination (logging of allocation of information)
  - Supporting behavior (logging of forwarding of ‘missed’ messages)

- **Team effectiveness**
  - Objective errors in evacuation plan
Results – Information processing

**Opened messages**

- Threat: 2.0
- No Threat: 3.0

\[ t(24) = 1.77, p < .05, d = 0.72 \]

**Degree of overview**

- Threat: 3.0
- No Threat: 3.5

\[ t(24) = -2.52, p < .01, d = 1.03 \]
Results – Degree of control

**Leadership control**
- Threat: \( t(24) = -2.87, p < .01, d = 1.17 \)
- No Threat: \( t(24) = 1.87, p = .04, d = 0.76 \)

**Participative Leadership**
- Threat: \( t(24) = 2.58, p < .01, d = 1.05 \)
- No Threat: \( t(24) = 1.25, p = .22, d = 0.50 \)

**Deliberation**
- Threat: \( t(24) = 2.58, p < .01, d = 1.15 \)
- No Threat: \( t(24) = 3.25, p < .01, d = 1.40 \)
Results – Collaboration and effectiveness

<table>
<thead>
<tr>
<th></th>
<th>Threat</th>
<th>No Threat</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Coordination</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$t(24) = 2.20, p &lt; .05, d = 0.90$</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Supporting behavior</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$t(24) = 1.75, p &lt; .05, d = 0.71$</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Errors</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$t(24) = -5.04, p &lt; .01, d = 2.06$</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Conclusions study 1

Threat
- Restriction in Information processing
  - Less attention to peripheral info
  - Lack of overview
- Constriction in control
  - Leaders exert more control
  - Leaders are less participative
  - Team members deliberate less
- Narrowing of team perspective
  - Reduced coordination
  - Less supporting behavior

Reduced team effectiveness
Study 2

Mitigating the Effects of Threat on Teams through Training
Theory & Hypotheses

- How can the negative effects of threat be mitigated?

- Prior research suggests: Cross-training
  
  *Each team member is trained on tasks, duties, and responsibilities of all other team members to develop shared mental models (SMM)*
  
  - Positive effects on communication, coordination, and effectiveness
  - Not very practical
  - Not time-efficient

- Alternative: focus on distribution rather than sharedness → distinction between Transactive Memory Systems (TMS) and Shared Mental Models
Transactive Memory Theory (Wegner, 1987, 1995)

Transactive Memory System

- Set of individual memory systems
- Shared awareness of who knows what

Benefits

- Cognitively efficient
  - Reduced cognitive load
  - Expanded pool of expertise
  - Reduced redundancy
- Improved planning
- Improved coordination
- Buffer against threat?
Newly developed TM-training

TM-training:

Highlight distribution of expertise in team and address strategies to combine distributed expertise effectively

Goal:

• Awareness of distributed expertise
• Awareness of interdependency
• Facilitation of coordination

Elements:

• Positional clarification
• Guided group discussion
Design & Results

- 174 participants (officers cadets, Netherlands Defence Academy)
- 58 three-person teams
- Military evacuation scenario in PLATT
- 2 factors: Threat (high vs. low) X TM-training (training vs. no training)

- Threat negatively affected:
  - Transactive Memory
  - Coordination
  - Performance monitoring

…only in teams that did not receive training, **but not in teams that did receive training**
Conclusions study 1 and 2

- Threat
- Restriction in information processing
- Constriction in control
- Narrowing of team perspective
- Reduced team effectiveness
- TM-training
Consequences for C2

- Threat may seriously influence the C2 approach dimensions

- Restriction in information processing
- Constriction in control
- Narrowing of team perspective
- Broad information distribution
- Broad allocation of decision rights
- Unconstrained patterns of interaction
Implications for C2 Research

- Include threat (or other stressors) in research design:
  - Allows for fair comparison between ‘traditional C2’ and edge C2
  - Edge C2 also better option with threat…?

- Integrate real complexity in research environments:
  - Rule-based actions do not suffer under threat!
  - Complexity is inherent in current military operations
  - Unfamiliarity, high dynamism, multiple goals, no standard solutions

- Investigate methods to counter threat-effects
  - Training and instruction methods
  - …?
Implications for C2 Practice

- Very nature of Edge C2 may make it vulnerable to the effects of threat

- Position on all dimensions shifts back to origin:
  - Revoked
  - Constrained
  - Restricted

- Threat thus may lead to a ‘relapse’ in C2 approach

- Relapsing from edge leads to:
  - Loss of large amounts of information
  - Authority that lacks knowledge to make decisions

- Worse than starting with less capable C2 approach!
Implications for C2 Practice

- **NNec C2 Maturity Model**
  “Operating at a high C2 maturity level makes it possible to select different C2 approaches”

- **In case of threat:**
  - If task does not require edge C2 → Select less capable C2 approach
  - If task does require edge C2 → Be prepared for the risks of threat

- **Preparation:**
  - Creating awareness of threat effects
  - Selecting the right people
  - Providing appropriate training
  - Monitoring C2 processes
  - Timely adjusting rigid tendencies

- Eventually, the human factor is the decisive factor!