Team Composition: Linking Individual and Team Characteristics to Team Decision-Making and Performance

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Motivation and Rationale

Complex endeavors build increasingly on network-enabled collaboration.

The focus of R&D efforts is gradually shifting from technological sophistication and quality of infrastructure to human factors.

To date little is known about which human factors contribute to a networked team’s effectiveness, and how.
NCW Tenets

Information Domain
- Quality of Information
- Robustly Networked Force
- Information Sharing

Cognitive Domain
- Shared Situational Awareness
- Collaboration
- Self Synchronization

Physical Domain
- Mission Effectiveness

Social Domain
This is where the “magic” happens ...
Research Question and Variables

- What team composition in regard to psychological factors supports the quality of collective decision-making and performance in a networked team? – What are the effects of specified individual and team characteristics on team performance?

- **Input (independent) variables**
  - **Individual characteristics**
    - Extraversion – Introversion
    - Sensing – Intuition
    - Thinking – Feeling
    - Judging – Perceiving
    - Locus of Control
    - Ambiguity Tolerance
  - **Team-specific characteristics**
    - Task Cohesion
    - Social Cohesion

- **Output (dependent) variables**
  - Team performance
    - Team effectiveness
    - Team efficiency
    - Shared Situational Awareness
### Individual Characteristics – MBTI®

<table>
<thead>
<tr>
<th>Extraversion</th>
<th>Introversion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Communicate actively</td>
<td>Appear reserved and passive</td>
</tr>
<tr>
<td>Decide and act fast</td>
<td>Strive to deeply analyze things</td>
</tr>
<tr>
<td>Tendency for impulsivity</td>
<td>Reflect things long before acting</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sensing</th>
<th>Intuition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interested in details, facts, figures</td>
<td>See the „big picture“</td>
</tr>
<tr>
<td>Realistic, pragmatic, benefit-oriented</td>
<td>Creative, future-oriented</td>
</tr>
<tr>
<td>Favor approved strategies</td>
<td>Favor unconventional solutions</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Thinking</th>
<th>Feeling</th>
</tr>
</thead>
<tbody>
<tr>
<td>Think in terms of „cause and effect“</td>
<td>Judgements based on beliefs</td>
</tr>
<tr>
<td>Try to decide rationally, act logically</td>
<td>May appear irrational in decisions</td>
</tr>
<tr>
<td>Performance-oriented</td>
<td>Oriented toward others‘ needs</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Judging</th>
<th>Perceiving</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value unambiguousness</td>
<td>Preserve alternatives</td>
</tr>
<tr>
<td>Planful, value orderly procedures</td>
<td>Tendency for tardiness</td>
</tr>
<tr>
<td>Dislike time pressure</td>
<td>Deal with time pressure easily</td>
</tr>
<tr>
<td>Tend to be inflexible, change resistant</td>
<td>Value spontaneity and flexibility</td>
</tr>
</tbody>
</table>
### Other Individual/Team Characteristics

<table>
<thead>
<tr>
<th>Locus of Control: Internal</th>
<th>Locus of Control: External</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Believe to be in control over one's own life</td>
<td>- Believe that one's life is controlled by fortuity or influential others</td>
</tr>
<tr>
<td>- Attribute success and failures to one's own acting (ability, effort)</td>
<td>- Attribute success and failures to (bad) luck or influential others</td>
</tr>
<tr>
<td>- High achievement motivation</td>
<td>- Lower achievement motivation</td>
</tr>
<tr>
<td><strong>Ambiguity Tolerance: High</strong></td>
<td><strong>Ambiguity Tolerance: Low</strong></td>
</tr>
<tr>
<td>- Positive attitude toward ambiguous information and uncertainty</td>
<td>- Negative attitude toward ambiguous information and uncertainty</td>
</tr>
<tr>
<td>- Perceive ambiguity as challenging</td>
<td>- Perceive ambiguity as stressful</td>
</tr>
<tr>
<td>- Willingness to take risks in the face of incomplete or ambiguous info</td>
<td>- Tendency to avoid risks in the face of incomplete or ambiguous info</td>
</tr>
<tr>
<td><strong>Task cohesion</strong></td>
<td><strong>Social cohesion</strong></td>
</tr>
<tr>
<td>- Shared commitment to group goals</td>
<td>- Perceived team member similarity</td>
</tr>
<tr>
<td>- Subordinate personal goals to group</td>
<td>- Sympathy for fellow team members</td>
</tr>
<tr>
<td>- Willingness to cooperate to achieve group goals</td>
<td>- Perceived integration into the team</td>
</tr>
<tr>
<td>- Performance-stimulating interactions</td>
<td>- Willingness to work with fellow team members on future tasks</td>
</tr>
</tbody>
</table>

**Locus of Control:**
- **Internal:** Believe you have control over your life, attribute success to your own action, have high achievement motivation.
- **External:** Believe your life is controlled by chance or others, attribute success to luck, have lower achievement motivation.

**Ambiguity Tolerance:**
- **High:** Positive attitude towards ambiguity, perceive ambiguity as challenging, willingness to take risks.
- **Low:** Negative attitude towards ambiguity, perceive ambiguity as stressful, tendency to avoid risks.
Hypotheses

**Main effects:** Hypotheses 1a – 6a (Individual characteristics):

Team-level (1a) Extraversion, (2a) Sensing, (3a) Thinking, (4a) Judgment, (5a) Internality is positively related to team performance.

(6a) Team-level Ambiguity Tolerance is related to team performance in an inverted-U-shaped way.

**Hypothesis 7 – 8 (Team characteristics):**

(7) Social cohesion, (8) Task cohesion is positively related to team performance.

**Moderator effects:** Hypotheses 1b – 6b:

The higher team heterogeneity in

(1b) Extraversion, (2b) Sensing, (3b) Thinking, (4b) Judgment, (5b) Internality, and (6b) Ambiguity Tolerance is, the lower is the correlation between the respective team-level variable and team performance.
Research Design

Step 1: Theory-based development of hypotheses on relationships
Input variables → Team performance

Step 2: Data Collection

2a: Measurement of individual-level variables (Questionnaires)
2b: Collaboration experiments (Simulation game)
2c: Measurement of team-specific variables (Questionnaires)

Step 3: Data Analysis

3a: Quantitative analyses: Output measures, Test of hypotheses

(3b: Qualitative analyses: Process description and interpretation)

Step 4: Discussion of results and implications
Collaboration Experiments

CAFFEINE: „Collaborative Game for First Experiences in a Networked Environment“ (Schäfer, 2005)
Setting

- 130 teams of four spatially distributed participants (German Air Force officer cadets) connected through local computer networks
- Two experimental conditions: Common Result Picture (CRP), Individual Result Picture (IRP)
Task assignment

Find the 7 hidden targets!

Game sequence:
4 recce runs,
1 “strike“ run
Recce runs and tools

- Specified budget and (set of) sensors available per player and run
- Sensors of different
  - price per deployment,
  - coverage,
  - reliability.

Sensor example:

Tornado Recce

Price per Deployment: 20
Coverage: 2 horizontal * 2 vertical
Risk of Non-Detection: 10%
Risk of False Alarm: 5%
Deployment Area: UNLIMITED
Displayed Recce Result Picture

Sensor E: „Target located“

Sensor F: „Area clean“

Select display of results:
Each player may execute up to 9 “strikes“ at the 7 hidden targets.

Conflicting tactics: Utilize all 9 strikes versus risk as few errors as possible.

Players may strike independently or (partly) coordinated with fellow team members.

Team top score (Maximum effectiveness): Each player has hit all targets, no errors.

Shared awareness (SA): Maximum overlap among the targets stroke by the team members. High SA is a necessary but non-sufficient prerequisite for high effectiveness.
Displayed Final Results Picture

- False Alarm
- Missed target
- Hit
CAFFEINE Overview

- Submit move
- Select sensor
- Display final results
- Submit Message
- Chat
- Current run/current budget
- Display results of single runs
- Information on sensors
- Information on sensors
- Display results of single runs
- Submit Message
- Chat
- Select sensor
- Display final results
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- Chat
## Final Results Table

<table>
<thead>
<tr>
<th>PLAYER</th>
<th>HIT</th>
<th>FAIL</th>
<th>START</th>
<th>END</th>
<th>TOTAL</th>
<th>CHAT</th>
<th>WB</th>
<th>SCORE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alpha 1</td>
<td>5</td>
<td>3</td>
<td>21:01:50</td>
<td>21:04:52</td>
<td>03:02</td>
<td>0</td>
<td>0</td>
<td>61</td>
</tr>
<tr>
<td>Alpha 2</td>
<td>4</td>
<td>4</td>
<td>21:00:01</td>
<td>21:05:13</td>
<td>05:12</td>
<td>0</td>
<td>0</td>
<td>25</td>
</tr>
<tr>
<td>Alpha 3</td>
<td>4</td>
<td>3</td>
<td>20:58:29</td>
<td>21:05:29</td>
<td>07:00</td>
<td>0</td>
<td>0</td>
<td>29</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>TEAM</th>
<th>HIT</th>
<th>FAIL</th>
<th>START</th>
<th>END</th>
<th>TOTAL</th>
<th>CHAT</th>
<th>WB</th>
<th>SCORE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>13</td>
<td>10</td>
<td>20:58:29</td>
<td>21:05:29</td>
<td>07:00</td>
<td>0</td>
<td>0</td>
<td>139</td>
</tr>
</tbody>
</table>
### Comparing CRP and IRP

<table>
<thead>
<tr>
<th></th>
<th>Minimum</th>
<th>Maximum</th>
<th>Average</th>
<th>s. d.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CRP</td>
<td>IRP</td>
<td>CRP</td>
<td>IRP</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hits</td>
<td>12</td>
<td>9</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>Errors</td>
<td>0</td>
<td>0</td>
<td>14</td>
<td>20</td>
</tr>
<tr>
<td>Time (sec.)</td>
<td>135</td>
<td>158</td>
<td>1053</td>
<td>1599</td>
</tr>
<tr>
<td>Chat Msgs</td>
<td>0</td>
<td>0</td>
<td>65</td>
<td>156</td>
</tr>
<tr>
<td>Budget left</td>
<td>0</td>
<td>0</td>
<td>485</td>
<td>385</td>
</tr>
<tr>
<td>Performance</td>
<td>0.5</td>
<td>0.0</td>
<td>17.8</td>
<td>11.7</td>
</tr>
<tr>
<td>Shared Av.</td>
<td>1.46</td>
<td>1.38</td>
<td>4.00</td>
<td>4.00</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>T&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>- 8.52**</td>
</tr>
<tr>
<td></td>
<td>7.60**</td>
</tr>
<tr>
<td></td>
<td>9.45**</td>
</tr>
<tr>
<td></td>
<td>9.18**</td>
</tr>
<tr>
<td></td>
<td>- 5.26**</td>
</tr>
<tr>
<td></td>
<td>-10.13**</td>
</tr>
<tr>
<td></td>
<td>- 7.44**</td>
</tr>
</tbody>
</table>

<sup>a</sup> T-Tests for paired samples; ** p < .01

#### Frequencies of achieved performance scores

- CRP
- IRP

![Bar chart showing frequencies of achieved performance scores for CRP and IRP](chart.png)
## Regression Results

<table>
<thead>
<tr>
<th>Independent and Control Variables</th>
<th>Task effectiveness</th>
<th>Task efficiency</th>
<th>Shared Awareness</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>R²</td>
<td>β&lt;sup&gt;a&lt;/sup&gt;</td>
<td>T</td>
</tr>
<tr>
<td>Absolute term</td>
<td>.18</td>
<td>.01</td>
<td>-.24</td>
</tr>
<tr>
<td>Extraversion – Introversion</td>
<td>.15 1.44</td>
<td>.30 3.07**</td>
<td>.04 .40</td>
</tr>
<tr>
<td>Sensing – Intuition</td>
<td>-.02 -.20</td>
<td>.03 .26</td>
<td>.05 .46</td>
</tr>
<tr>
<td>Thinking – Feeling</td>
<td>-.01 -.13</td>
<td>-.01 -.12</td>
<td>.01 .09</td>
</tr>
<tr>
<td>Judging – Perceiving</td>
<td>.26 2.74**</td>
<td>.22 2.38*</td>
<td>.16 1.67*</td>
</tr>
<tr>
<td>Locus of Control internal</td>
<td>.18 1.88*</td>
<td>.17 1.81*</td>
<td>.13 1.35</td>
</tr>
<tr>
<td>Ambiguity Tolerance</td>
<td>.02 .22</td>
<td>-.03 -.38</td>
<td>.08 .85</td>
</tr>
<tr>
<td>Control variables:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intellectual ability numeral</td>
<td>-.02 -.23</td>
<td>.07 .78</td>
<td>.09 .89</td>
</tr>
<tr>
<td>Intellectual ability figural</td>
<td>.03 .28</td>
<td>-.04 -.44</td>
<td>.02 .17</td>
</tr>
<tr>
<td>Age</td>
<td>-.11 -1.10</td>
<td>-.16 -1.69*</td>
<td>-.09 -.91</td>
</tr>
<tr>
<td>Number of females</td>
<td>-.01 -.12</td>
<td>-.03 -.28</td>
<td>-.14 -1.48</td>
</tr>
</tbody>
</table>

<sup>a</sup> Standardized Beta (regression weights);
Significance levels: + p < 0.10; * p < .05; ** p < .01
Results

Main effects: Team efficiency is positively related to team-level
(1a) Extraversion: significant in opposite direction
(2a) Sensing: not supported
(3a) Thinking: not supported
(4a) Judgment: significant in opposite direction
(5a) Internality: supported

Team efficiency is related to (6a) Ambiguity Tolerance in an inverted-U-shaped way: not supported

Team performance is positively related to
(7) social cohesion: supported
(8) task cohesion: supported

Moderator effects: The correlation between team-level variable and team efficiency is the stronger, the lower team heterogeneity in this variable is.
(1b) Extraversion: supported
(2b)-(6b): not supported
Practical implications (1)

Locus of Control

To manage complex endeavors, agile organizations decentralize and delegate decision rights to self-organized teams. These should be able to recognize their abilities to exert control over outcomes of their decisions.

*Leadership and training should provide ample performance feedback and nurture self-efficacy and achievement motivation.*

Judging – Perceiving

In complex and dynamic environments, cognitive flexibility and the willingness to adapt to changes meet the requirements of network-enabled operations better than (too) early decision-making and acting.

*Complex endeavors require cultural change and new strategies for personnel selection and training toward cognitive complexity and adaptability.*
Practical implications (2)

Extraversion – Introversion
Strong extraversion may negatively influence team performance – if text chat is the only available communication medium.

Utilizing specified communication media requires adjustment of team composition and training (communication skills).

Task cohesion
Commitment to team goals and the superordinate purpose promote team performance substantially.

To promote delegation of decision rights and responsibilities, training efforts should support teams in developing shared understanding of the endeavor’s significance and purpose.

Social cohesion
Social cohesion promotes performance even in “ad hoc” teams. It is a valuable resource for teams from the very beginning of an endeavor.

Social cohesion should be nurtured carefully, while being aware of the risks of unfavorable group dynamics.
Qualitative analyses

What factors of emergent human (communication) behavior contribute to a networked team’s effectiveness?

Main areas:

- **Task-knowledge coordination:**
  What are the key factors in task-knowledge coordination that distinguish effective from ineffective networked teams?

- **Decision-making processes:**
  In what terms do processes differ between effective and ineffective networked teams?

- **Communication patterns:**
  In what terms do observed communication patterns differ between effective and ineffective networked teams?

- **Emergent team roles:**
  In what terms do emergent team roles and emergent (shared) leadership differ between effective and ineffective networked teams?
### Selected Results (1)

<table>
<thead>
<tr>
<th>Task-knowledge coord.</th>
<th>Effective teams (N=12) / Ineffective teams (N=12)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Locate expertise</td>
<td>Communicate who has which sensors: Yes / No</td>
</tr>
<tr>
<td>Divide task</td>
<td>„Filter strategy‖ / „Quadrant strategy‖</td>
</tr>
<tr>
<td>Integrate subtasks</td>
<td>Evaluate recce results / Report pre-evaluated results</td>
</tr>
<tr>
<td></td>
<td>Develop target list / No shared target list</td>
</tr>
<tr>
<td>Coordinate decisions</td>
<td>Target list jointly developed / No agreement on targets</td>
</tr>
<tr>
<td>and actions</td>
<td>Concerted actions / Autonomous (pre-mature) actions</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Decision process</th>
<th>Effective teams (N=12) / Ineffective teams (N=12)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plan info collection</td>
<td>Comprehensive and shared / At best short notice</td>
</tr>
<tr>
<td>Collect information</td>
<td>Follows joint planning / Overlaps with previous phase</td>
</tr>
<tr>
<td>Integrate information</td>
<td>Integrate jointly / Report unsystematically, no feedback</td>
</tr>
<tr>
<td>Assess options</td>
<td>Evaluate options carefully / Pre-evaluate, little agreement</td>
</tr>
<tr>
<td>Strike targets</td>
<td>Follows joint decision / Overlaps with option evaluation</td>
</tr>
</tbody>
</table>
## Selected Results (2)

### Communication patterns

<table>
<thead>
<tr>
<th></th>
<th>Effective (N=12)</th>
<th>Ineffective (N=12)</th>
<th>T</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strategy (suggest strategy)</td>
<td>4.1</td>
<td>1.5</td>
<td>-2.30*</td>
</tr>
<tr>
<td>Guidance (influence attempts)</td>
<td>11.7</td>
<td>9.0</td>
<td>-2.10*</td>
</tr>
<tr>
<td>Coordination (assess status, coordinate)</td>
<td>12.9</td>
<td>7.0</td>
<td>-2.44*</td>
</tr>
</tbody>
</table>

Absolute number of sent messages; T = T-Test statistic; * p < .05; ** p < .01

### Emergent roles

<table>
<thead>
<tr>
<th>Emergent roles</th>
<th>Effective teams (N=12)</th>
<th>Ineffective teams (N=12)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emergent leadership</td>
<td>Leadership attempts accepted / neglected</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Whole process / only at beginning or toward end</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Efforts made by emergent leader to integrate results and promote joint evaluation process: high / low</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Emergent leaders make sure that all members participate / do not care about participation</td>
<td></td>
</tr>
<tr>
<td>Proactive followership</td>
<td>Member engagement in proactive followership: high / low</td>
<td></td>
</tr>
</tbody>
</table>
Qualitative Study: Practical Implications

Task-knowledge coordination:
Sufficiently exchange information on available resources (expertise location, available methods/tools, etc.) at the very beginning

Decision-making process:
Improve “maturity” of collaborative capability through true resource sharing and sophisticated coordination

Communication patterns:
Focus on task-related communication (procedural/coordination matters), constructive conflict communication

Emergent team roles:
Train and develop various leadership roles and behaviors; nurture proactive followership, promote shifting leadership
Limitations and Suggestions for Future Research

- Sample characteristics:
  - Homogeneity in participants’ personality characteristics
  - Sample size in qualitative study: (12 + 12 teams)

- Generalizability:
  Moderate complexity of employed game as compared to endeavors in the “real world”

- Future research
  - Role of increased task complexity
  - Impact of intercultural differences on collaboration in multinational teams and between teams of different nations
  - Role of tailored training and/or field experience of team members
Team Composition: Linking Individual and Team Characteristics to Team Decision-Making and Performance

13th ICCRTS, Bellevue, WA
19 June 2008

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