Human-system collaboration and communication methods in a synthetic test environment

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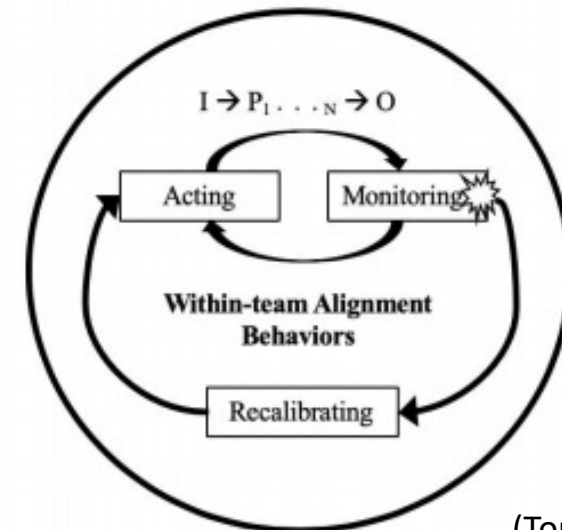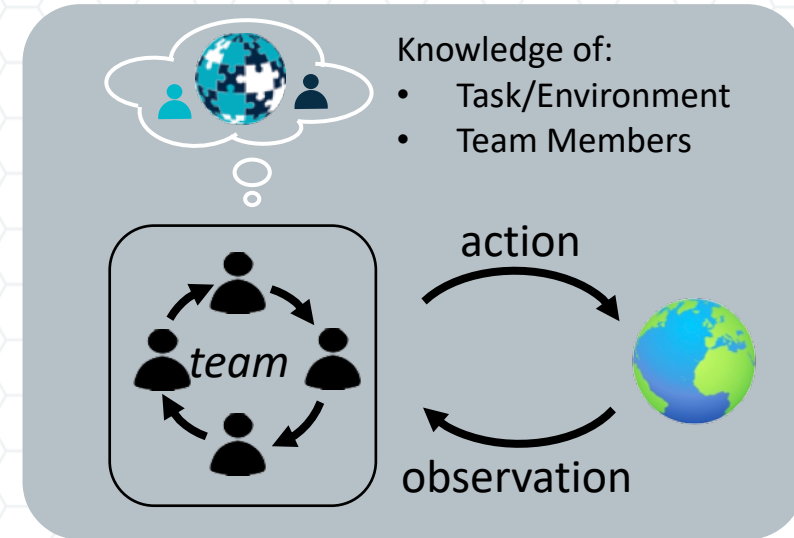
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Edward Weiss, James Cook, Cate Merfeld, and Adam Fouse

- The problem – why do we need to research Human-AI teams?

- Minecraft as a synthetic environment to test team dynamics

- Scenario development

- Longitudinal study design

- Lessons learned

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- As AI systems improve, we need to understand the psychology of humans teaming with AI systems (Seeber et al., 2020)

- Additional team members introduce complex team dynamics that must be understood for successful collaboration

- In operational contexts, overcompliance or undercompliance can be dangerous

- How does communication between AI and humans impact compliance?

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- These efforts are fundamentally motivated by creating hybrid human-AI teams

- To maximize the advantages and minimize the disadvantages of adding AI, we need:
  - Artificial systems that can be part of hybrid human-AI teams
  - Hybrid human-AI teams that align with mechanisms of human team adaptation

- When creating hybrid human-AI teams, it's not *just* about task-centered mathematical optimality
  - Systems need to consider how to *influence* teams -- how the impact of the AI on the team will lead to better overall outcomes considering the range of likely responses of human (and AI) team members

- When creating adaptive teams, we need mathematical models that are fundamentally about balancing success in the present with preparing for uncertain futures
  - Need to support *team-level adaptation* instead of just individual adaptation

Knowledge of:
- Task/Environment
- Team Members

action

team

observation

(Torres et al., 2021)

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Research Goal

Focus on AI guidance adherence

- Goal: Identify and quantify the factors that impact increases adherence to guidance
- Understand the conditions under which humans are more/less likely to follow AI guidance
- How does this impact team formation and behavior over time?

Does whether advice is asked for impact compliance?

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Synthetic Test Environment

- Urban Search and Rescue scenario

- Don't want to place people in dangerous scenarios

- Need flexibility to change scenarios

- Psychological realism

- Minecraft allows "modding"
  - APIs
  - De-obfuscated code
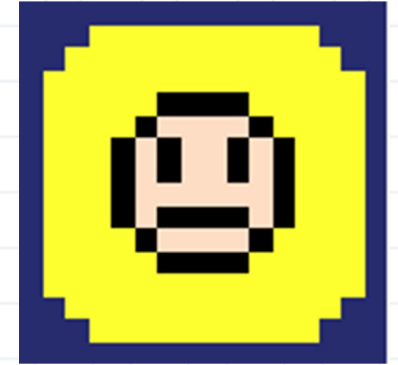 - Custom objects implementation and registration via hooks

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Timer

Victims

- Medic saves victims

- Hammer specialist clears rubble

- Transporter moves victims

- Markers store information about the mission

How do we encourage teamwork?

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Roles have resource and temporal interdependencies and constraints, both with each other and the state of the mission

Hard Dependencies
Players must work together to complete a task

Soft Dependencies
Efficiency is increased if players work together

Need medic to get points

Need hammer specialist to clear rubble

Variety of problems

Multiple strategies work

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- Saves victims
- Average speed
- Medical kit saves ⅓ of victims

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Rubble Specialist

- Rubble blocks sections of the map → Need hammer specialist to clear the rubble.

- Slow

- Hammer breaks quickly

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- Ability to pick up and move victims
- Fast
- Unlimited uses

- Store information on the map

- Free up cognition for complex teamwork

Clear room

Victim in room

Rubble Blockage

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Introduce a **new problem**

Think of **real world problems** in Search and Rescue

What goals do you have?
- Disrupt team behavior
- Encourage communication
- Introduce cognitive load

Rubble Perturbation

- Randomly, more rubble would fall blocking hallways.
- Introduces an immediate problem that needs to be addressed
  - Forces teams to be flexible and dynamic

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- 3 gas leak blocks spawn around the map in 6 possible locations

- Players can fix the gas leaks by right clicking with their tools

- Each gas leak counts as 5 victims

Client Map

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Player Position

Guidance

A5
A4
A3
A2
A1

B8 B9
B7
B5 B6
B2 B3 B4
B1

LH4
LH3
LH5 LH6
LH2
LH1

C8
C7
C6
C5
C4
C3
C2
C1

CH3
D6
D5
D4 D3
D2
D1

CH2
E2
E1

CH1

RH5
F4 G4
F3 G3
F2 RH2 G2
F1 G1

RH1

H6
H5
RH4
H4
RH3
H3
H2
H1

Your callsign : Red

MISSION TIMER: 9 : 2

GUIDANCE FROM AGENT

More rubble has fallen. Its always good to have an engineer or two handy in these situations. Coordinate with your team to spread out and address it.

Given @ :10 : 1

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- "AI" messages based on pre-coded rules

- Exploration vs exploitation

- Strategic advice and specific advice

  - Team composition

  - Communication

  - Efficient use of time

  - Victim locations

- More useful in earlier games, unless guidance isn't followed

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- Using the Minecraft mod, we captured player data
  - Movement
  - Interactions with the world
  - Tool usage
  - Where the player is looking

- This data is key for the Artificial Intelligence agent to understand team dynamics

- Provides behavioral data with minimal effort

Study design

- Longitudinal: 4 teams of 3 players over 6 weeks for a total of 36 game plays per team
- Conditions
  - Push / pull
  - Pull / push
- Independent variable: communication type
- Dependent variables
  - Number of victims saved (score)
  - Guidance compliance (was action directed by AI taken within time frame)
  - Helpfulness rating (post survey)
  - Number of times suboptimal conditions occur where guidance is available (in pull condition) or sent (in push condition) over time
  - Areas visited that are free of victims or that contain victims
  - Number of marker blocks placed

- Participants also filled out surveys after each session (1 session = 6 runs).

- Included variables such as:
  - Perceived performance, engagement, and helpfulness of self, team, and AI agent
  - Perceptions of likelihood of future trust in and reliance on AI agent
  - Open-ended opportunity to leave comments regarding session.

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- Compare across Push and Pull conditions:
  - Number of victims saved (score)
  - Number of guidance messages given
  - Guidance compliance (proportion of guidance complied with)
  - Helpfulness rating (post survey)

- Assess relationships between:
  - Victims saved and guidance compliance
  - Victims saved and perceptions of AI variables
  - Perceptions of AI variables and perceptions of performance and engagement

- Assess changes in performance and perceptions over time:
  - Changes in victims saved
  - Changes in perceptions of AI, teammates, and self

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Key Takeaways:

- Perceptions of performance and trust

  - Self, teammates, and AI agent

- Communication of AI guidance and performance

Considerations from our study:

- Strong within-persons study, small sample size for between-persons/team effects.

- Potential ceiling effects on performance

  - Data showed variability even through the end of the study

- Implications for human behavior, in teams or solo

Thank you!

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