Beyond Dyadic Interactions: Assessing Trust Networks in Multi-Human-Robot Teams

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About the authors

Aakash (@nimrobotics) a third-year Ph.D. candidate in the at UW-Madison. His research interests span human-robot interaction, neuroergonomics, and affective computing.

Dr. Ranjana Mehta is a professor at UW-Madison. Ranjana Mehta's research examines the mind-motor-machine nexus using a novel neuroergonomics approach to understand, monitor, and predict human performance under fatigue and stress.

Background

- Separate workspace
- No human

- Separate workspace
- Shared part

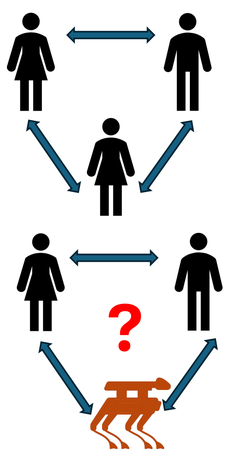
- Same workspace
- Same part
- Single human

- Same workspace
- Same goal
- Multiple humans

Human Robot Teaming

- **Trust** in human-robot collaboration can impact system performance, acceptance, safety, and utilization
  - **Undertrust** can lead to underutilization of the robot's capability
  - **Overtrust** can pose a critical safety problem
  - In all human teams, intrateam trust has been shown to significantly impact team performance
- **mHRT**: interdependence, common goal, distinct roles
- Need for mHRT
  - Robots:
    - mapping, navigation, sensor suite, payload, communication beacon
    - Reduce response and recovery time, operate in hot zones
  - "it takes two humans to operate one robot" in emergency response

Trust networks



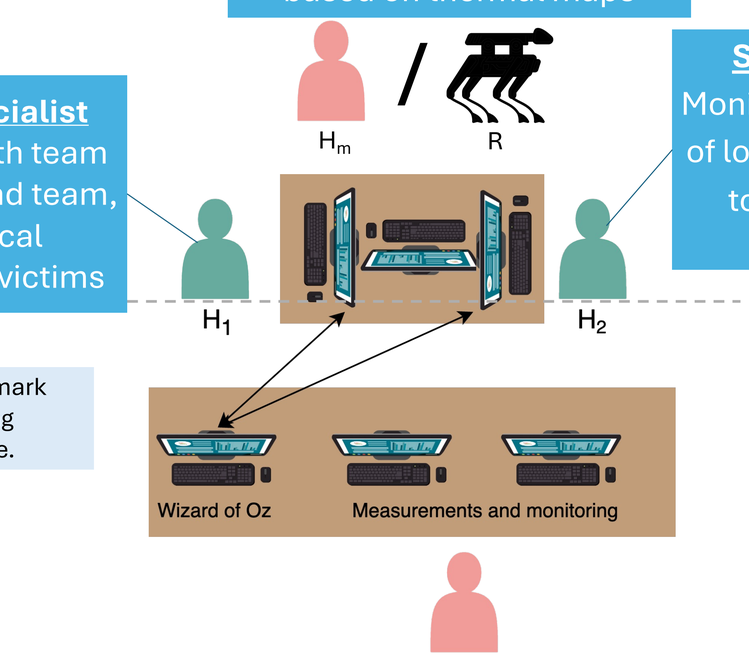
Methods

46 participants (20 females, 26 males) to form n = 23 teams (7 male-male, 4 female-female, and 12 male-female)

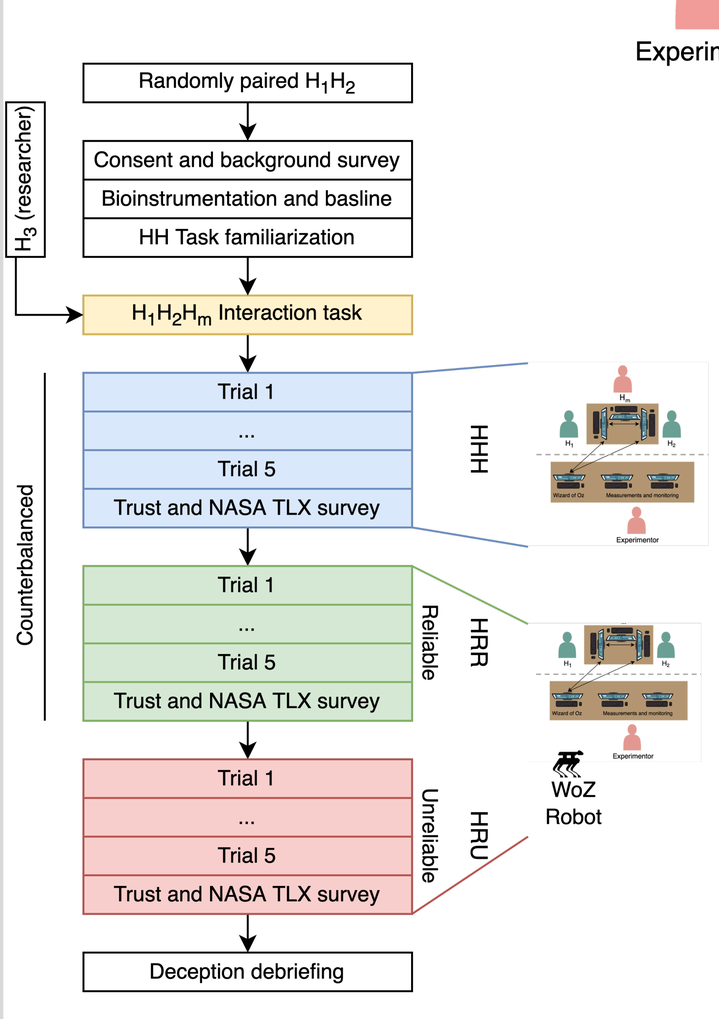
Navigator
Guided team by suggesting directions to locate victims based on thermal maps

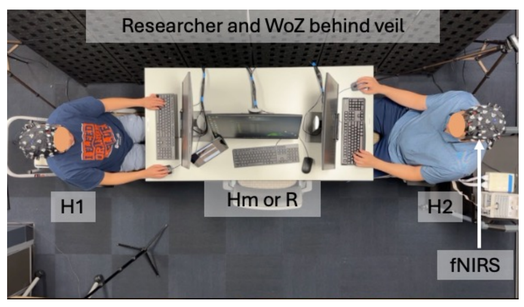
Mission Specialist
cooperated with team members to lead team, made critical decisions, log victims

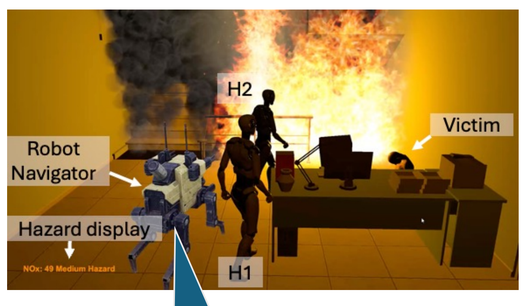
Safety Officer
Monitored NOx levels of low, medium, high to ensure team safety



Task: Locate and mark victims in a burning building in set time.





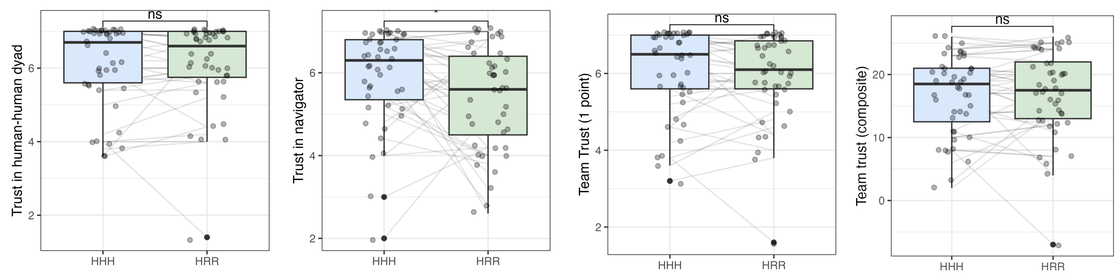


Wizard of Oz robot

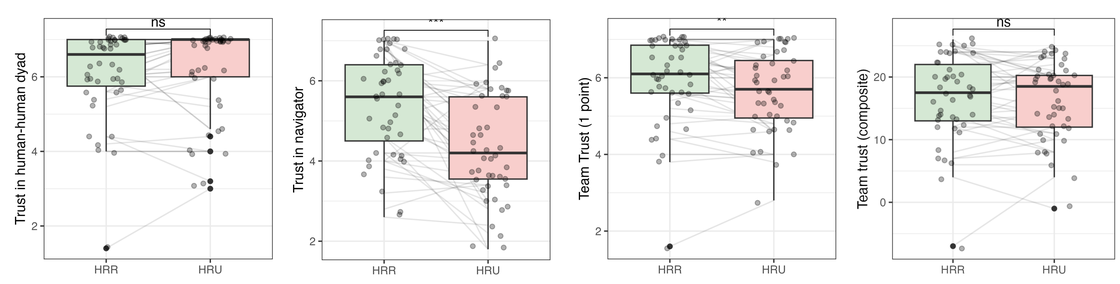
Results

Trust metrics

All human team vs multi-human robot team



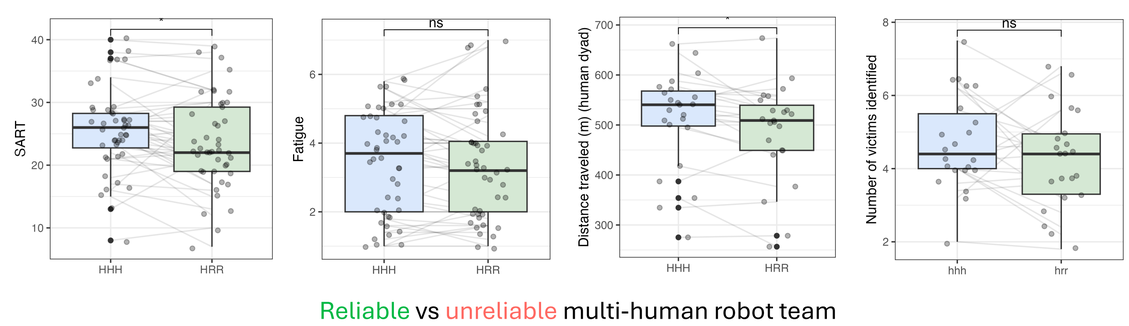
Reliable vs unreliable multi-human robot team



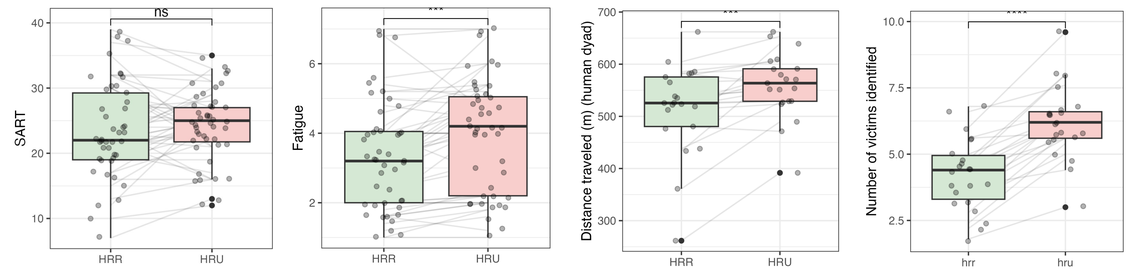
- Team trust ratings did not change with the addition of a reliable robot.
- Team trust decreased when working with an unreliable robot.

Situation awareness, fatigue, and performance measures

All human team vs multi-human robot team



Reliable vs unreliable multi-human robot team



- Working with reliable robot reduced situation awareness.
- Fatigue perception increased with unreliable robot.
- Distance traveled and victims located increased in unreliable conditions.

Path trajectories across the trials

Key takeaways

- We designed a virtual task environment to assess trust networks in multi-human-robot teams.
- Team trust remained intact with the addition of a reliable robot to the team, even though the robot navigator was trusted less.
- Introducing a robot teammate led to changes in team behaviors, such as reduced travel, warranting in-depth analysis of behavior and performance metrics.
- Emergent behaviors in mHRT involved adaptive strategies by engaging in continuous independent exploration, highlighting the dynamic adaptation within teams to overcome challenges and optimize task outcomes.
- Future work will focus on performing trust assessments in a real-world environment.

References

- Robin R Murphy. 2014. Disaster robotics. MIT press.
- M.C. Cohen, M. Demir, E.K. Chiou, and N.J. Cooke. 2021. The Dynamics of Trust and Verbal Anthropomorphism in Human-Autonomy Teaming (2021 IEEE 2nd International Conference on Human-Machine Systems (ICHMS)). Piscataway, NJ, USA, 6 pp.
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- Robin R Murphy. 2004. Human-robot interaction in rescue robotics. IEEE Transactions on Systems, Man, and Cybernetics, Part C (Applications and Reviews) 34, 2 (2004), 138–153

Image source (top left robots): Kawasaki, Universal Robots

Lab webpage