Task-Allocation Decisions of Human-UAS Collaboration: Effects of Workload, Trust, and Self-confidence

Yining "Elena" Zhang & Jing Chen Rice University
Liang Sun Baylor University
Bin Hu University of Houston
Michael S. Politowicz & Eric T. Chancey NASA Langley Research Center

HFES ASPIRE 09/12/2024

Outline

1. Background
2. Method
3. Participants
4. Results
5. Conclusion

AAM and Human Autonomy Teaming

Advanced Air Mobility (AAM)

- Technology advancement and traffic concerns
- Applications: package delivery, passenger carriage, and emergency services [1]
- Subsets: commercial aircraft, urban air taxis, and small uncrewed aerial vehicles [2]

Human Autonomy Teaming

- m:N operation architecture [3]
- Physical separation between pilots and aircraft
- Task delegation and handoffs due to fatigue, specialization, and workload [4]

Task Allocation/ Assignment Decision

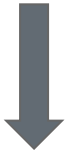
[1] Cohen & Shaheen, 2023; [2] Advancing Aerial Mobility: A National Blueprint, 2020; [3] Chancey and Politowicz, 2020; [4] Tvaryanas, 2006

What would the experts choose?

Who would you choose to **perform** this subtask, yourself or automation?

Responsibility

Would you choose to **assign** this subtask manually or automatically?



Authority

Human Autonomy Teaming

Workload

- Higher: Increased number of drones and contingencies [1]
- Automation design matters [2]
- High: lead to more handoffs [3]

Trust

- Under: poor team performance [4]
- Over: complacency, lack of situation awareness, and over-reliance on automation [5,6]

Self-Confidence

- High confidence and low trust: a preference for manual operation [7]
- High: in adaptive automation condition [8]

[1] Dixon et al., 2005; [2] Lee & Seppelt, 2012; [3] Chandarana et al., 2022; [4] McNeese et al., 2021; [5] Lee & See, 2004; [6] Onnasch et al., 2014; [7] Lee & Moray, 1994; [8] de Visser & Parasuraman, 2011

Measures

Workload: NASA-TLX [1]

Trust: Trust in Automation Questionnaire [2]

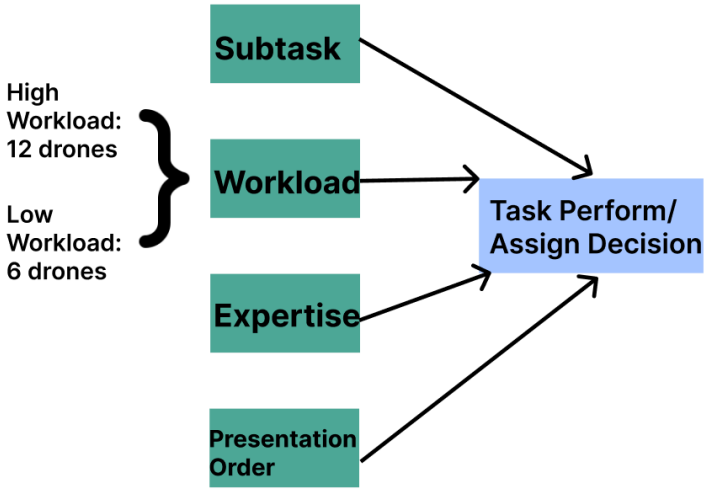
Self-confidence: one-item, seven-point Likert style [3]

Order: 6-drone or 12-drone presented first

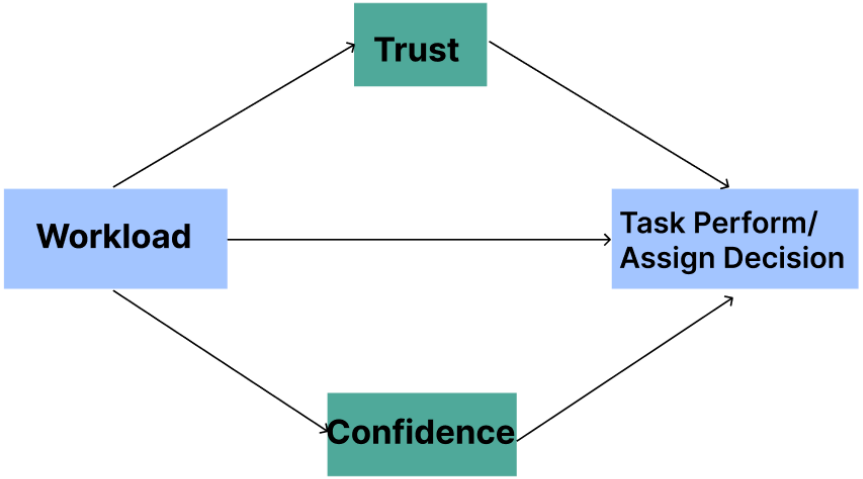
Task Allocation & Task Assignment Decision: Sliding scale from 0 (manual) to 100 (automation)

[1] Hart & Staveland,1988; [2] Jian et al., 2000, [3] Patton et al., 2023

Model 1



Model 2



Models

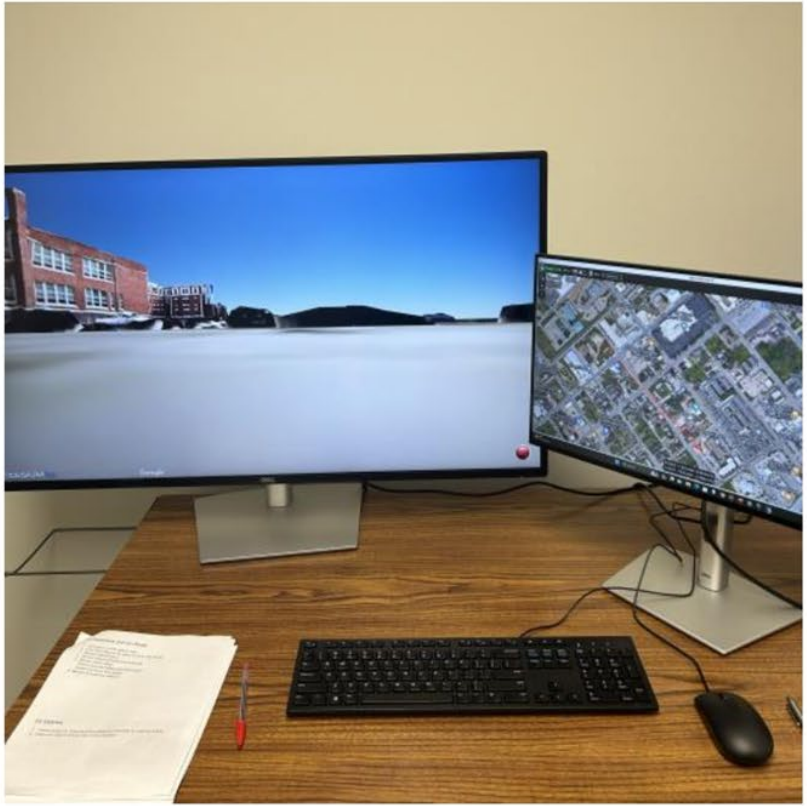


Fig. 1 Experiment set up: the simulated camera view of the drone (left) and the QGC interface (right)

Experiment Setup

Procedure

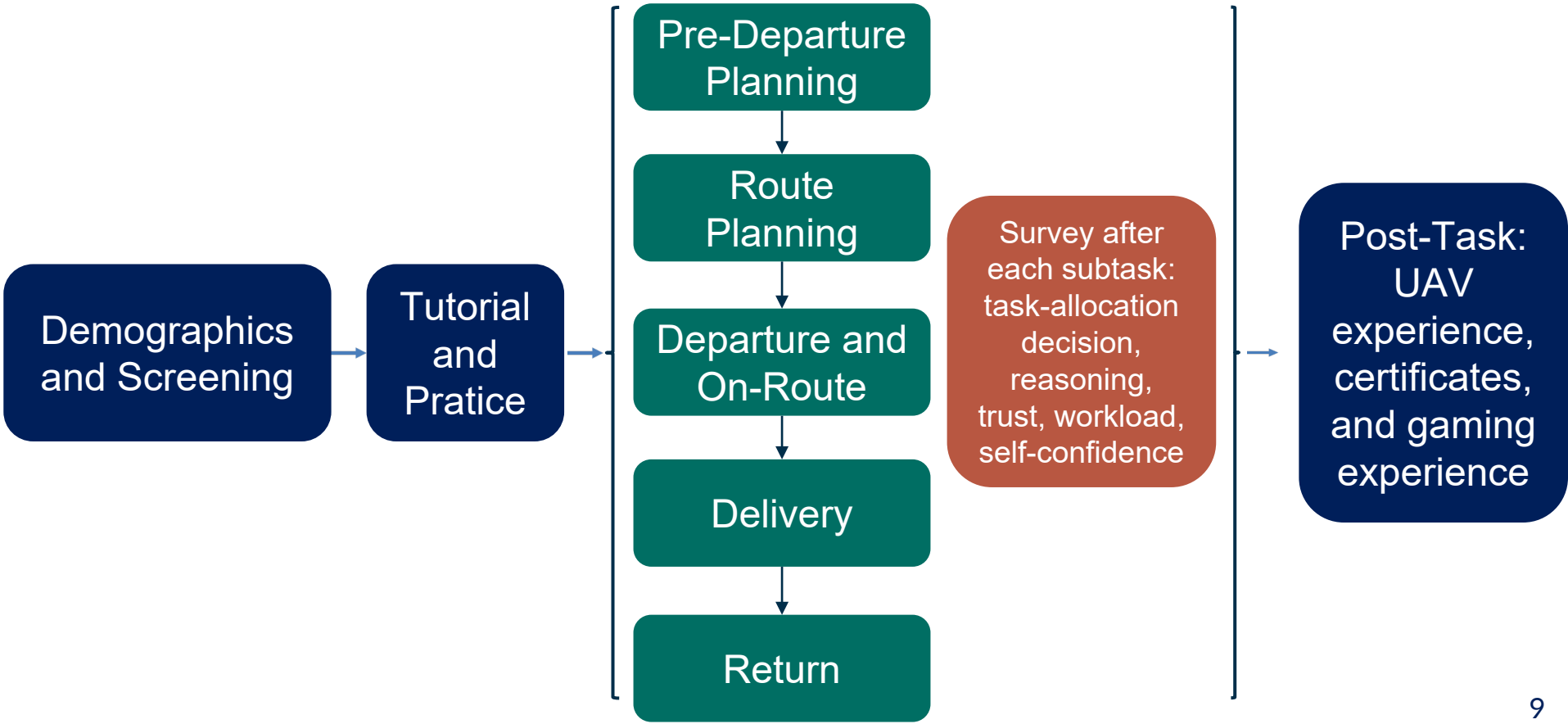
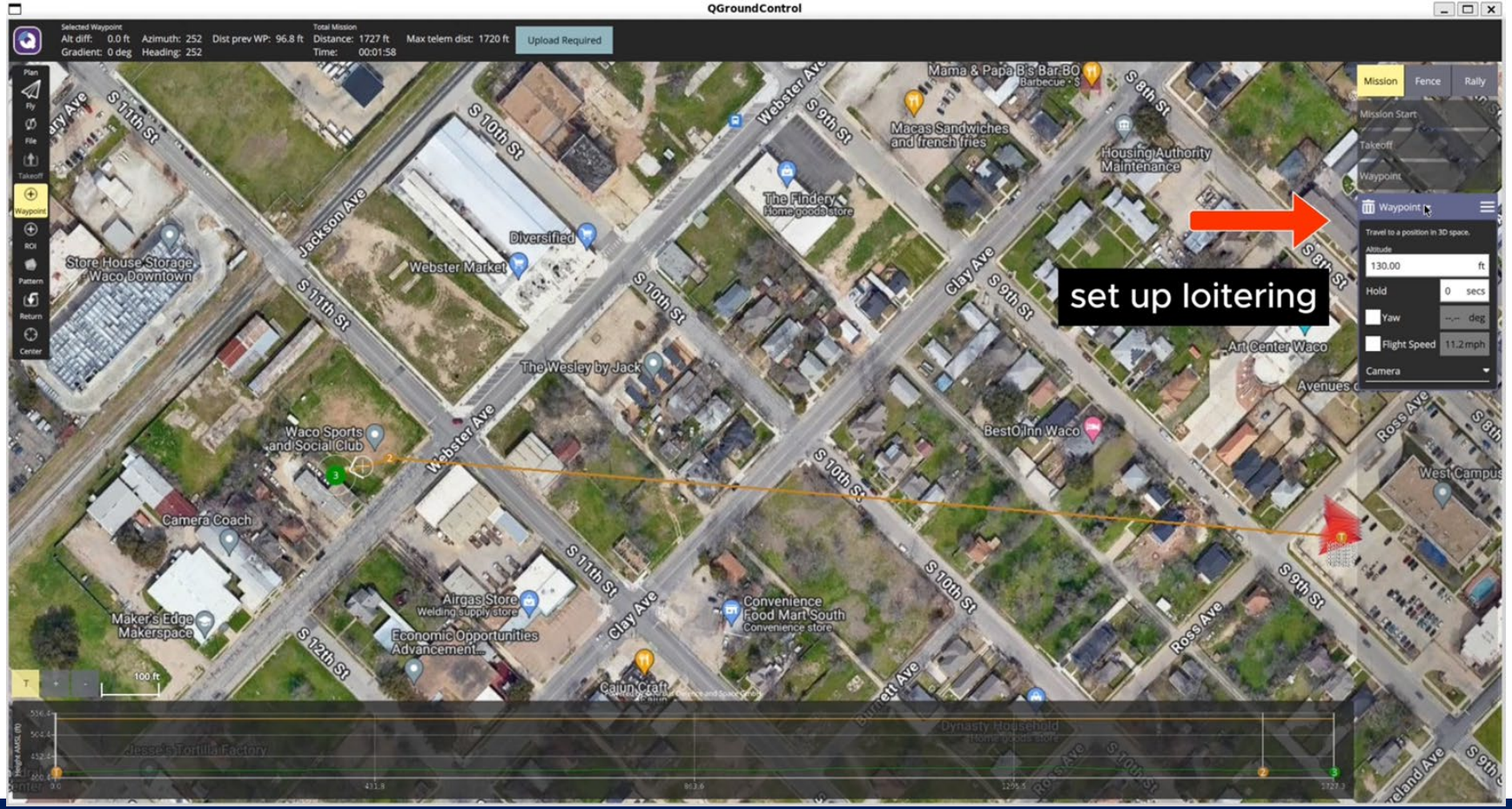

Demographics and Screening
Tutorial and Pratice
Pre-Departure Planning
Route Planning
Departure and On-Route
Delivery
Return
Survey after each subtask: task-allocation decision, reasoning, trust, workload, self-confidence
Post-Task: UAV experience, certificates, and gaming experience

Table 1 Subtask details

Subtask	Crucial Steps
Pre-Departure Planning	Set up vehicle speed, altitude, and geofence
Route Planning	Find delivery address on the map, set up waypoints, and set up loitering
Departure and On-Route	Select multi-vehicle view, start mission, confirm mission start, and monitor battery status
Delivery	Check surrounding environment for loitering safety
Return	Check GPS status, battery status, and landing environment

Partially based on https://wing.com/resource-hub/articles/how-drone-delivery-works/



Example Screenshot: Subtask “Route Planning”

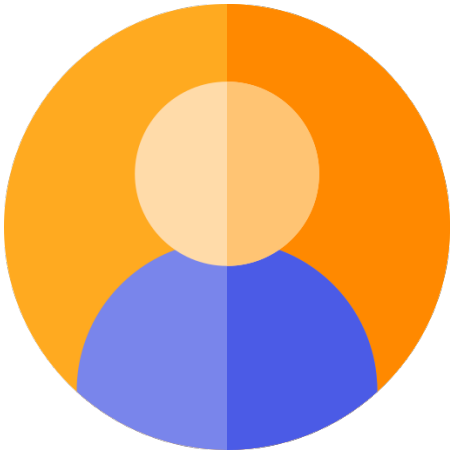
Software: QGroundControl

Example Screenshot: Subtask “Delivery”

Software and simulator: QGroundControl, AirSim (using Google Earth data for Waco, TX)

Participants

- 20 students
- Age: *M* = 25.30 (*SD* = 2.92)
- 4 males and 16 females
- Self-reported fly hours: *M* = .20 (*SD* = 0.52)

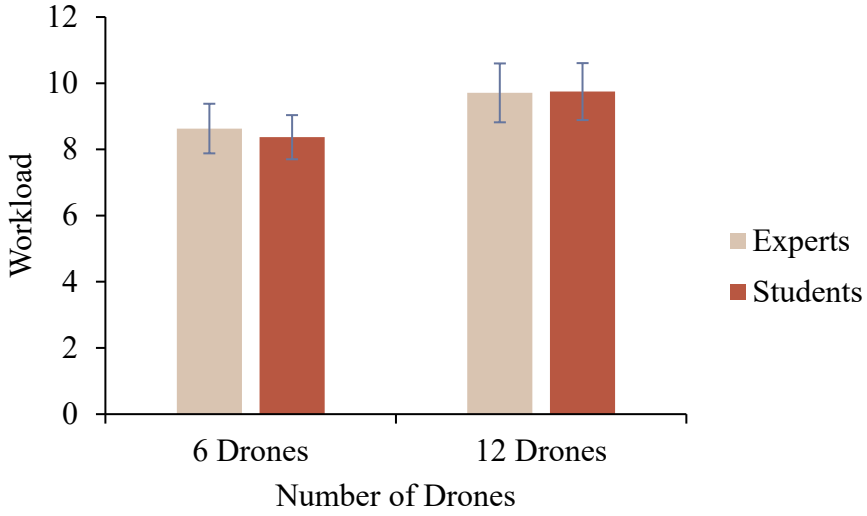


- 20 experts (Either have an FAA-certified Part 107 pilot license or at least 10 hours of experience)
- Age: *M* = 38.20 (*SD* = 10.41)
- 16 males and 4 females
- Self-reported fly hours: *M* = 225.53 (*SD* = 290.85)

User icons: https://www.flaticon.com/free-icon/user_1144709?term=profile&page=1&position=31&origin=search&related_id=1144709

Results: Number of Drones

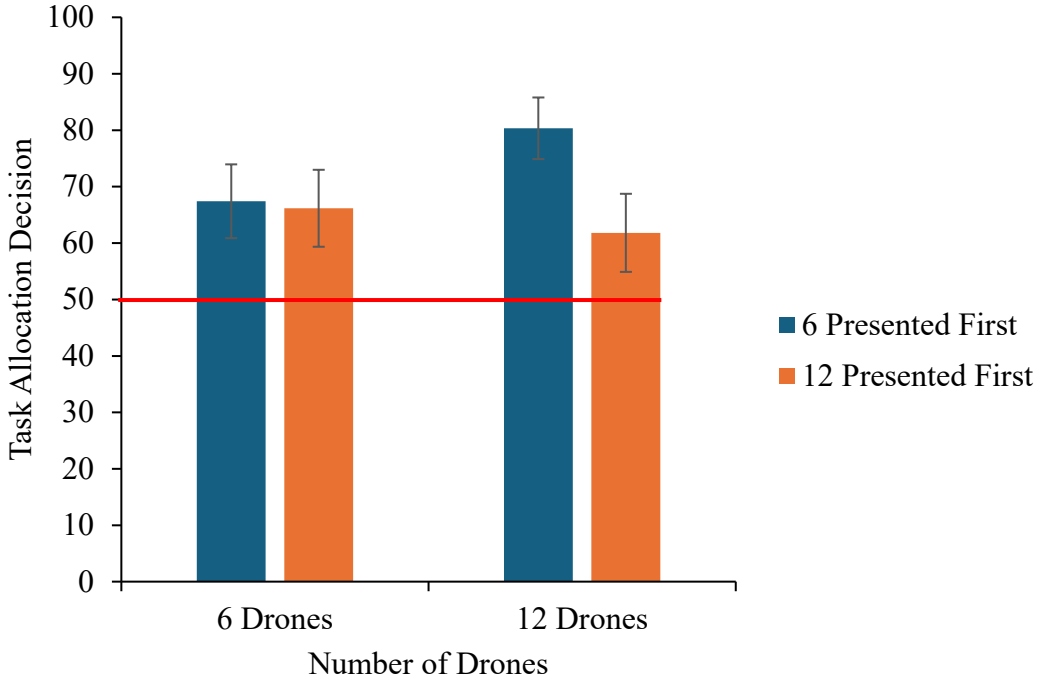
- The 12-drone condition reported a higher workload than the 6-drone condition.
- No significant difference in perceived workload between the expert and student samples in both conditions.



Error bars represent 95% Confidence Intervals.

Results: Task Allocation Decisions

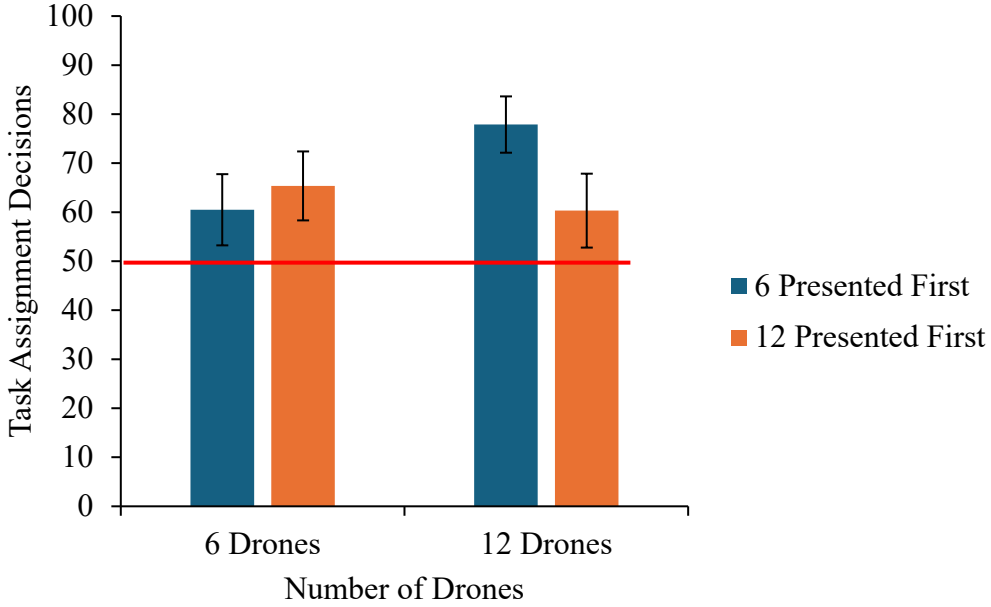
- **Significant interaction** between presentation order and number of drones.



Error bars represent 95% Confidence Intervals.

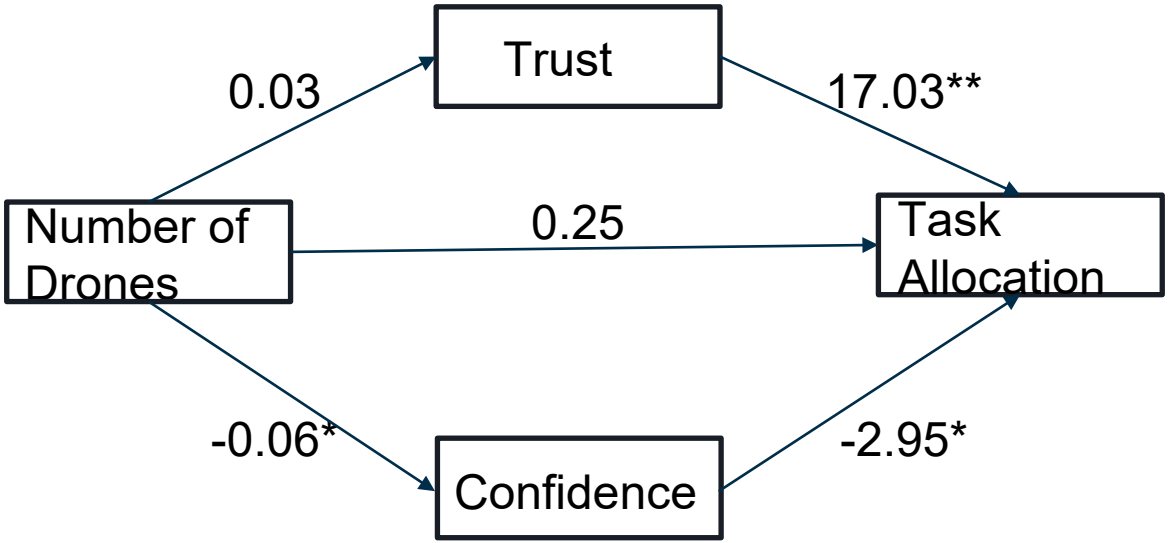
Results: Task Assignment Decisions

- The 12-drone condition had a higher preference for automation to assign tasks than the 6-drone condition.
- **Significant interaction** between presentation order and number of drones.



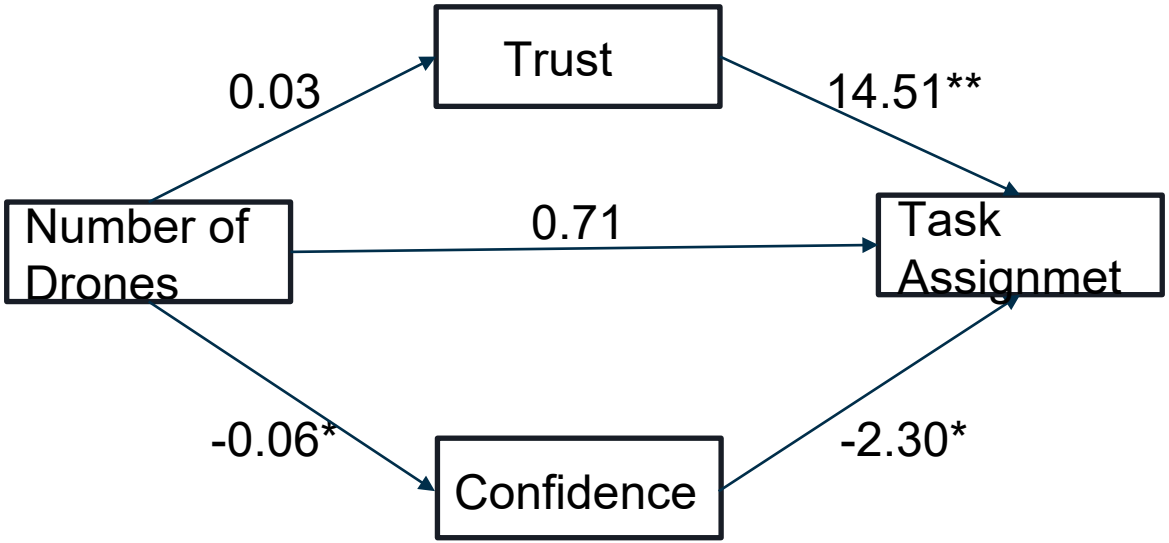
Error bars represent 95% Confidence Intervals.

Mediation Model: Task Allocation Decision



*indicates that the *p*-value is smaller than .05, ** indicates that the *p*-value is smaller than .001.

Mediation Model: Task Assignment Decision



*indicates that the *p*-value is smaller than .05, ** indicates that the *p*-value is smaller than .001.

Discussion

- **Contrary to past literature, experts and students did not show a significant difference in perceived workload or automation preference [1]**
  - Expertise level had a large variance in the expert sample
- **Self-confidence in manually performing the task significantly mediates the relationship between workload and automation preference [2, 3]**
  - Higher confidence leads to a higher preference for manual operation
- **Trust was not a significant mediator [3]**
  - The number of drones did not affect participants' perception of automation reliability
- **Preference for automation was the highest for subtask Return and lowest for subtask Delivery**
  - Participants had more safety concerns for subtask delivery compared to Return

[1] Riley, 1996; [2]Lee & Moray, 1994; [3] Patton, 2023; [4] Lee & See, 2004

Conclusions

- Perceived workload was higher when the number of drones increased
- There is a significant interaction between presentation order and the number of drones
- Self-confidence was a significant mediator between workload and automation preference
- Trust in automation was not a significant mediator
- Preference for automation to both perform and assign the tasks

Thank you!

This project is funded by the National Aeronautics and Space Administration under grant # 80NSSC23M0219.
Contact: jingchen@rice.edu

Yining "Elena" Zhang
Human Factors Engineer, UX Researcher and Designer