

How do VR interfaces and teleoperated manipulation tasks relate to task performance and perceived task difficulty?

Do selected operator characteristics explain additional variance beyond these factors?



### Background

**Teleoperation** can complement autonomous systems when intervention is required due to unexpected conditions, sensor defects, or ambiguous situations. [1] [2]

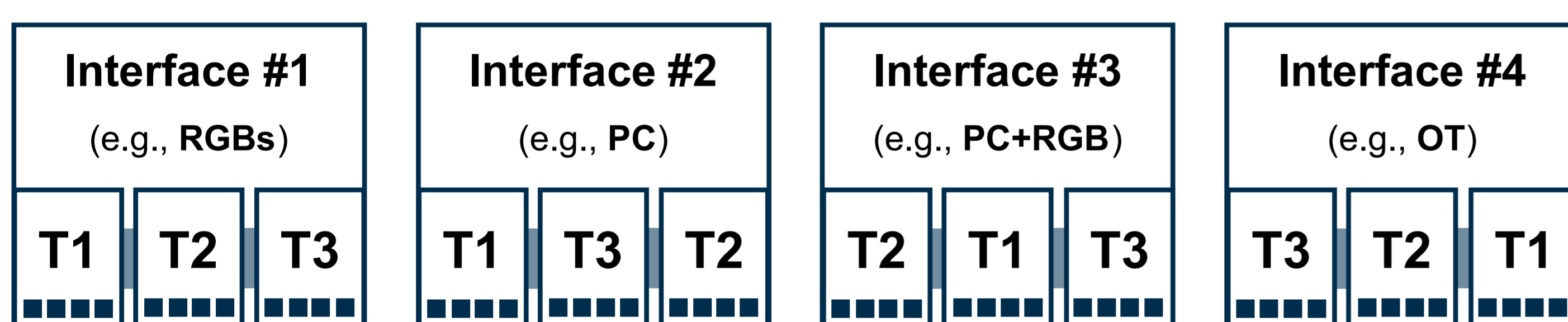
**Performance** depends on how effectively the interface provides task-relevant spatial relationships to the operator under time constraints and the cost of errors. [3] [4]

**VR-based leader-follower teleoperation setup** enables the direct remote control of a physical robot, providing an immersive 3D experience of the remote environment. [5]

### Human factors challenges in robot teleoperation

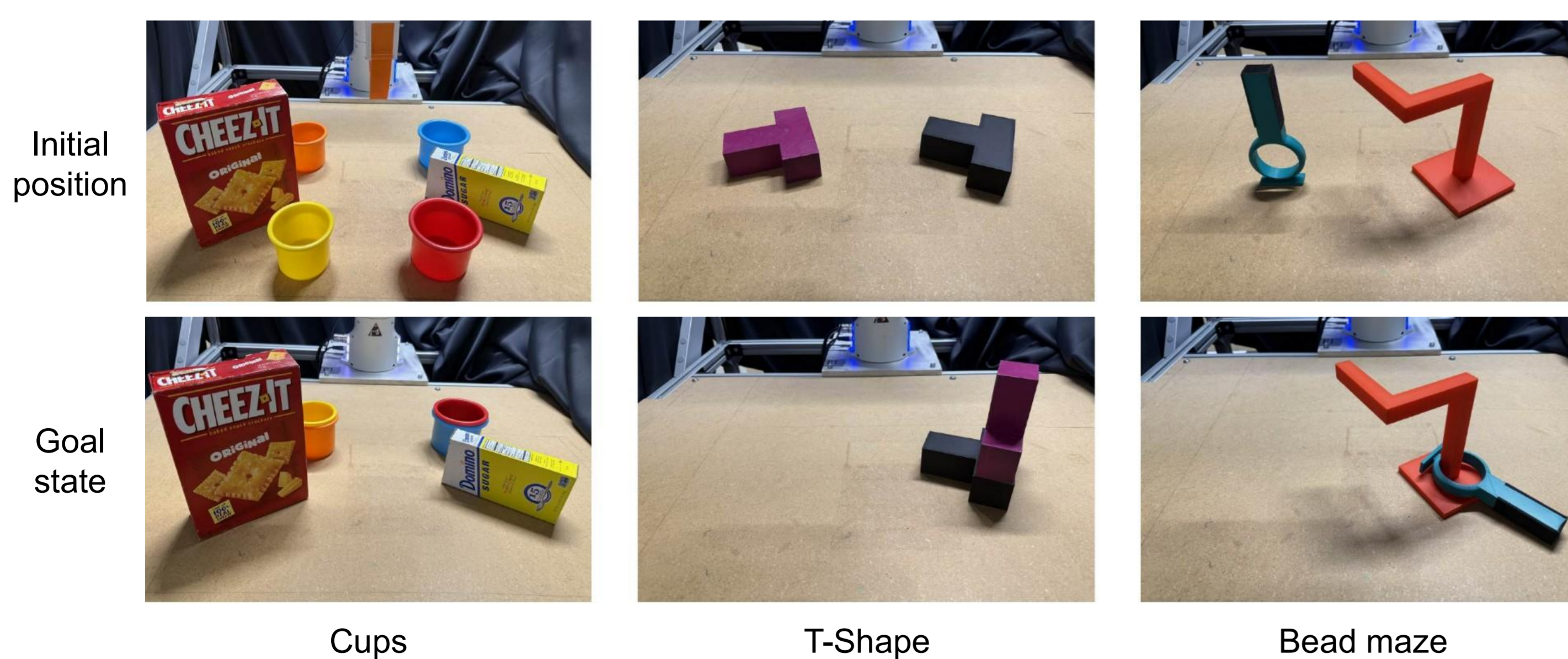
Operators must construct a usable representation of the remote environment from mediated information, which makes interface design critical for situation awareness and effective control. [3] [6]

### Methods



Subjective evaluation of the perceived workload and usability of each visualization modality.

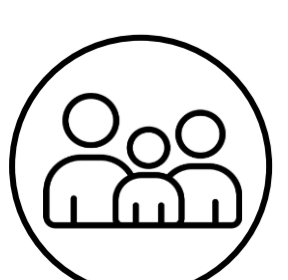
Oral evaluation of the perceived difficulty of each repetition within each task (T).



Cups

T-Shape

Bead maze



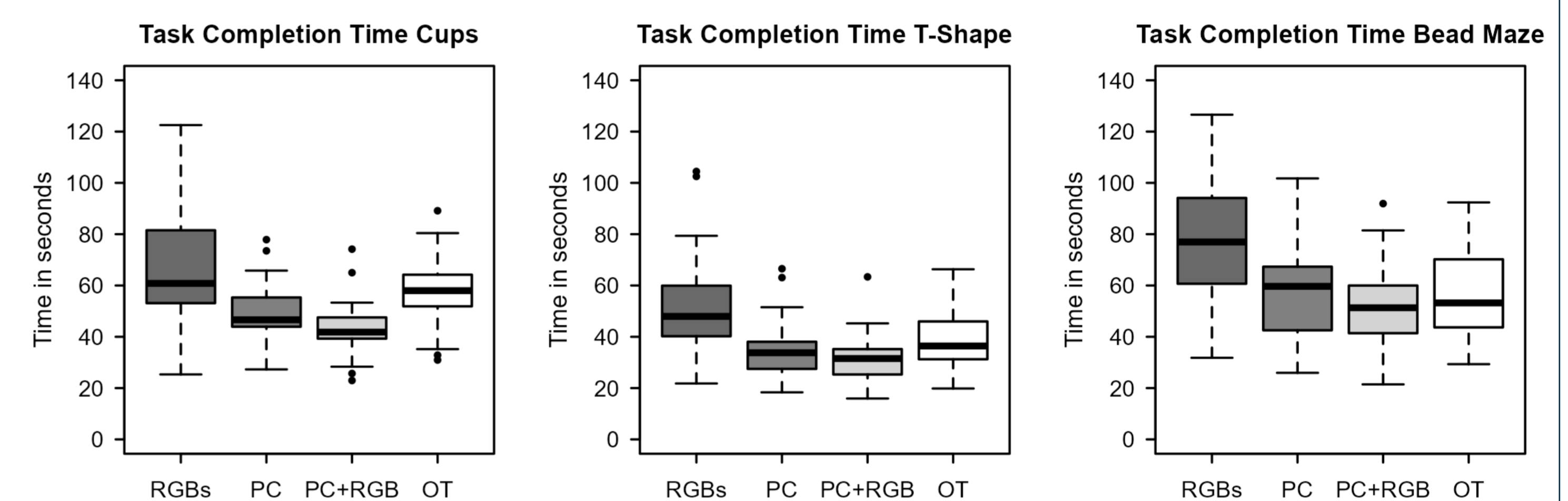
N = 35

8♂ 22♀ 1♀

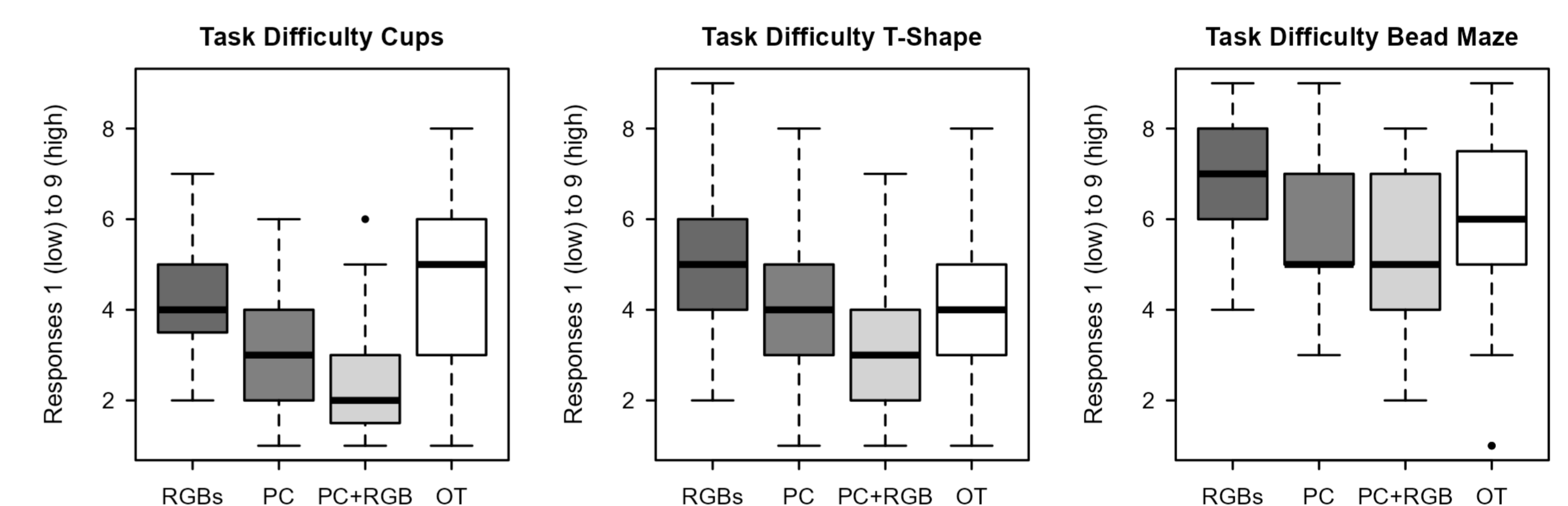
M<sub>age</sub> = 24.39 SD = 3.62

STEAM-oriented backgrounds

### Did the manipulation tasks and VR interfaces affect performance in teleoperation?



### Did the tasks and VR interfaces relate to perceived task difficulty during teleoperation?



### Did prior VR experience and mental rotation ability explain the variance in task performance?

- Participants with higher prior VR experience completed the tasks significantly faster across conditions ( $\chi^2(1) = 6.27, p = .012$ )
- Mental rotation ability did not show a significant main effect on task completion time ( $\chi^2(1) = 0.38, p = .54$ )

### Conclusion

**Task-relevant 3D spatial representations** are associated with faster task completion and a lower perceived task difficulty compared to RGB video.

**Task and system factors** explained most of the variance in performance and perceived difficulty, whereas **individual differences** contributed smaller, secondary effects.

**VR interface design** reduced the impact of individual differences, indicating that human-centered interfaces can support consistent performance among diverse operators.