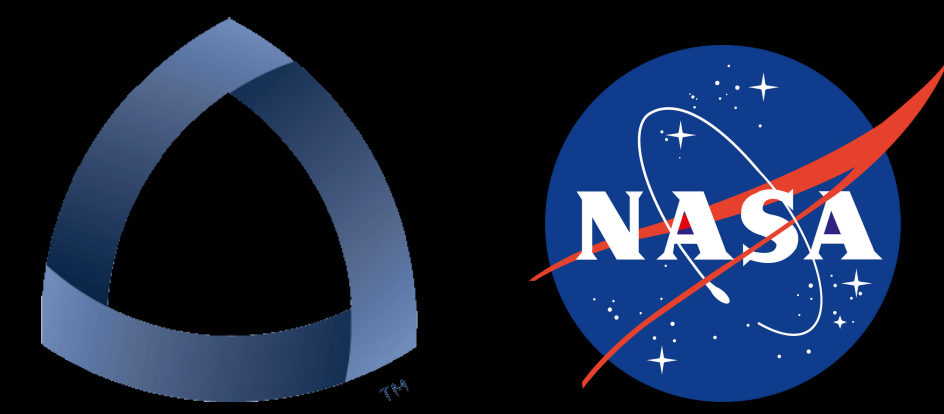


# Collabor-Action! Evaluating an Adaptive Model of Robot Performative Autonomy for Human-Robot Collaboration



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## Experiment Interface

Resources Game  
 Goal: Complete all building sites  
 Current Score: 1 / 15 Building Sites Completed

1 Resources  
 Red Reserve: 300 - 600  
 Blue Reserve: 0 - 60  
 Pink Reserve: 0 - 60  
 Orange Reserve: 0 - 60  
 Each building site costs 30 resources of each color!

2 Primary task (grid)

3 Robot video monitor

4 Number Game  
 When prompted, your task is to type in the number that was shown previously. For example, if you see numbers 3 and then 7, you should type 3 as it was seen one number previously.  
 Respond when the input box is visible. You'll have 10 seconds to respond.

5 Robot Question!  
 I was collecting red resources. Should I keep collecting red resources, or switch to collecting blue resources, or orange resources?  
 [Red] [Blue] [Orange]

- 1 Resource information
- 2 Primary task
- 3 Robot video monitor
- 4 Secondary task (n-back)
- 5 Awareness questions / Robot comm

## Can we increase situational awareness while maintaining low cognitive workload with adaptive autonomy?

- We developed an **online resource management game** and compared the effects of static models of **robot autonomy** to an **adaptive reinforcement-learning (RL)** based model
- We found that the **autonomy preferences** may be more important than **adaptive autonomy**

## Algorithm Development

### RL for Adaptive Autonomy

**State:** Human's cognitive state

**Reward:** Maximize situational awareness and minimize cognitive workload

**Action:** Change robot's level of autonomy

### RL Model Comparison

Model	Reward
Q-learning	1.016
Soft actor-critic	0.764
Deep Q	0.775

### Autonomy Level Models

SA \ CW	0	1	2	3
0	L	L	M	H
1	L	L	M	H
2	M	M	M	H
3	H	H	H	H

Heuristic

SA \ CW	0	1	2	3
0	M	M	H	L
1	M	M	H	H
2	M	M	L	L
3	M	M	M	H

Q-learning

## Lara Bezerra

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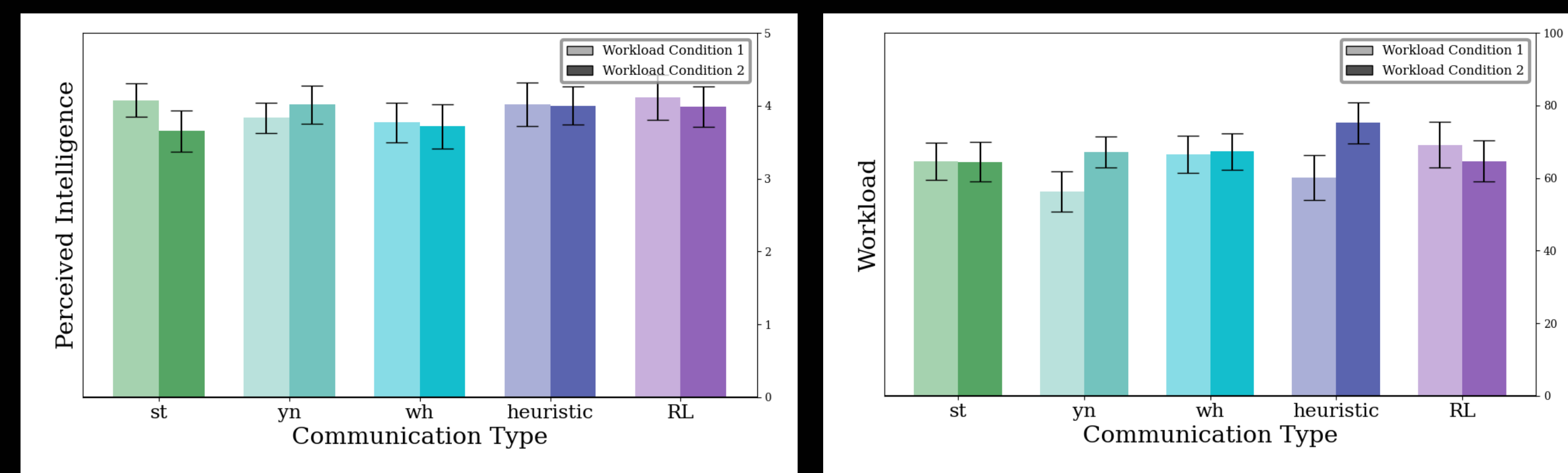
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## Quantitative Results



Extreme evidence (BF =  $5.6 \times 10^4$ )

Strong evidence (BF = 12.0)

- Extreme evidence (BF = 828.9) for comm. type on completion time
- Strong evidence (BF = 27.6) for workload on SA
- Strong evidence (BF = 0.085) *against* an effect of comm. type on perceived intelligence
- Moderate evidence (BF = 0.13) *against* an effect of comm. type on trust

## Qualitative Results

- Participants either wanted the robot to be *more or less* autonomous than it was:  
 "I would just let the robot do whatever it wants to do and not be burdened."  
 "I think I would allow the user to choose which color to collect."
- Some participants were confused by the heuristic model:  
 "Dynamic feedback was helpful but sometimes overly complex."
- Participants often thought the robot's communication was helpful but wanted more control over the frequency of communication

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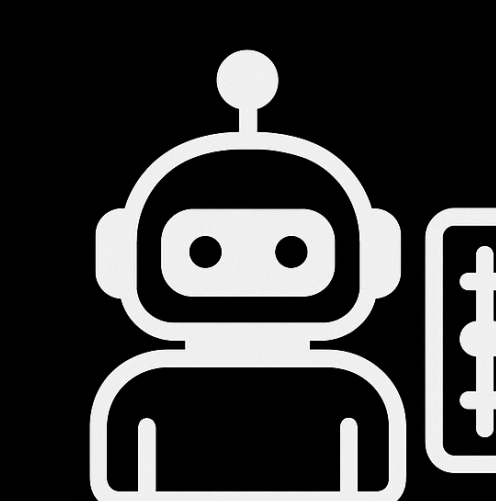
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## Takeaways

- Adapting to **personal preference** (adaptable model) for level of autonomy may be preferred to adaptive models based on **situational awareness** and **cognitive workload**
- Communication autonomy** does *not* impact **trust** or **perceived intelligence**, which is encouraging for other forms of adaptive and adaptable autonomy

Adaptable



vs

Adaptive

